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ABSTRACT

This instructor guide and the corresponding student reference contain five lessons about animal science for inclusion in Vocational Instructional Management System (VIMS) agricultural education courses. The lessons cover these topics: the monogastric digestive system, the ruminant digestive system, the importance of meeting nutritional needs, how to meet nutritional needs, and balancing a ration. The instructor's guide contains the following: objectives, competencies, motivational techniques, teaching procedures, other activities, activity sheets, transparency masters, evaluations, answers to evaluations and activity sheets, 20 references and teaching aids, materials and equipment lists, and a student competency profile. Four appendixes contain excerpts from university extension guides for nutrition requirements for beef and swine, and from feed composition tables. The student reference consists of information sheets and illustrations for the lessons. (KC)

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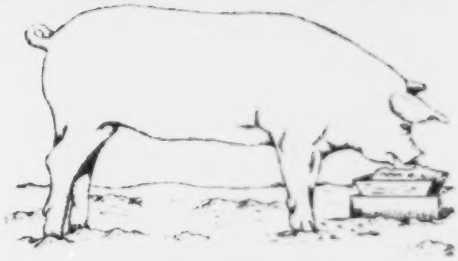
Introduction To

Animal Nutrition



Instructor Guide

In cooperation with
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Department of Practical Arts and
Vocational-Technical Education
College of Education and College of Agriculture,
Food and Natural Resources
University of Missouri - Columbia

In cooperation with
Agricultural Education Section
Division of Vocational and Adult Education
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INTRODUCTION TO ANIMAL NUTRITION

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FOREWORD

The development of the *Introduction to Animal Nutrition* curriculum guide is the result of suggestions by the MVATA Teaching Aids Committee. The Animal Nutrition Advisory Committee suggested the topics to be included and reviewed the materials.

This curriculum contains five lessons. The instructor's guide includes objectives, competencies, motivational techniques, teaching procedures, other activities, activity sheets, transparency masters, evaluations, answers to evaluations and activity sheets, references and teaching aids, and materials and equipment. Topics include the monogastric and ruminant digestive systems, the importance of meeting the nutritional needs of animals and how to meet them, and balancing a ration. An appendix is included that contains excerpts from University Extension guides on nutrient requirements and nutrient content of feeds that can be used as illustrations or to complete some of the activity sheets. One copy of the student reference is packaged with the instructor's guide. Additional copies of the student reference can be purchased separately.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed components to aid agriculture teachers in the implementation of VIMS. For ease of use, objectives and competencies have been included at the beginning of the guide as well as incorporated within each lesson. A competency profile has been provided in the front of the guide for convenient record keeping.

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INTRODUCTION TO ANIMAL NUTRITION

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COMPETENCIES/OBJECTIVES

1. Describe the parts and functions of the monogastric digestive system.
2. Describe the parts and functions of the ruminant digestive system.
3. Identify the importance of meeting the nutritional needs of animals.
4. Identify how the nutritional needs of animals may be met.
5. Demonstrate the procedure for balancing a ration for crude protein.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.
2. Observe the changes in behavior as evidence of the improved ability of students to deal with problems in this unit using background information acquired from earlier units.
3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

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2. Teacher References

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r. University Of Missouri - Columbia: University Extension agricultural publications

1) G2051: Feed Composition Tables
2) G2067: Nutrient Requirements for Growing and Finishing Beef Cattle
3) G2068: Nutrient Requirements for Beef Breeding Animals
4) G2320: Nutrient Requirements of Swine and Recommendations for Missouri

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Introduction to Animal Nutrition
Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 Mastered - can work independently with no supervision
2 Requires Supervision - can perform job completely with limited supervision
1 Not Mastered - requires instruction and close supervision
N No Exposure - no experience or knowledge in this area

3	2	1	N

Introduction to Animal Nutrition

1. Describe the parts and functions of the monogastric digestive system
2. Describe the parts and functions of the ruminant digestive system
3. Identify the importance of maintaining the nutritional needs of the animal
4. Identify how the nutritional needs of animals may be met
5. Demonstrate the procedure for balancing a ration for crude protein

Other:_____

_____

Introduction to Animal Nutrition

Student Names													

Competencies

1. Describe the parts and functions of the monogastric digestive system.
2. Describe the parts and functions of the ruminant digestive system.
3. Identify the importance of meeting the nutritional needs of animals.
4. Identify how the nutritional needs of animals may be met.
5. Demonstrate the procedure for balancing a ration for crude protein.

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 1: Monogastric Digestive System

Competency/Objective: Describe the parts and functions of the monogastric digestive system.

Study Questions

1. **Which animals have a monogastric digestive system?**
2. **What are the main parts of the monogastric digestive system?**
3. **What are the functions of the main parts of the monogastric digestive system?**
4. **What are the roles of digestive juices and enzymes in the digestion of nutrients?**

References

1. *Introduction to Animal Nutrition (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1996.
2. Transparency Masters
   a) TM 1.1: Swine Digestive System
   b) TM 1.2: Swine Digestive System (Overlay)
   c) TM 1.3: Horse Digestive System
   d) TM 1.4: Dog Digestive System
   e) TM 1.5: Rabbit Digestive System
   f) TM 1.6: Fowl Digestive System - Chicken
   g) TM 1.7: Enzymes in the Monogastric Digestive System
3. Activity Sheets
   a) AS 1.1: Swine Digestive System
   b) AS 1.2: Dissection of the Monogastric Digestive System
   NOTE: A monogastric digestive system can be obtained from a processing plant. The system should begin at the esophagus and end with the anus. It should be kept frozen until the dissection is performed.

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 1: Monogastric Digestive System

TEACHING PROCEDURES

A. Introduction

This book is an introduction to animal nutrition. In this book, monogastric and ruminant digestive systems will be covered, as well as the nutritional needs of animals. Balancing a feed ration to meet those nutritional needs will also be discussed. This lesson will discuss the monogastric digestive system. This type of digestive system is named for the simple, single compartment stomach that, together with the other parts of the system, enables an animal to digest food.

B. Motivation

Bring a grain and a hay sample to class. Ask which one a pig would eat and why.

C. Assignment

D. Supervised Study

E. Discussion

1. Not all animals have a monogastric digestive system. Ask students which animals are monogastric.

Which animals have a monogastric digestive system?

a) Swine
b) Horse
c) Dog
d) Rabbit
e) Fowl

2. Ask students what a monogastric digestive system is and discuss their answers. Remind students that while the liver, gall bladder, and pancreas are not a part of the digestive system itself, they are related organs that play an important role in digestion. Hand out AS 1.1 and, using TM 1.1, identify the parts along with the students. (An overlay with labels is provided in TM 1.2.) Use TM 1.3, 1.4, 1.5, and 1.6 to illustrate the digestive systems of the other species.

What are the main parts of the monogastric digestive system?

a) Mammalian digestive system
    1) Mouth
    2) Esophagus
    3) Stomach
    4) Small intestine - duodenum, remainder of small intestine
    5) Large intestine - cecum, colon, rectum
    6) Anus
b) Fowl digestive system
    1) Beak
    2) Gullet

3) Crop
4) Glandular stomach (or proventriculus)
5) Gizzard (or ventriculus)
6) Small intestine
7) Ceca
8) Large intestine
9) Cloaca
10) Vent

3. Each part of the monogastric digestive system has a function in processing feed. Ask students if they know what each function is. When discussing the functions of the parts, use TM 1.1 as an illustration.

What are the functions of the main parts of the monogastric digestive system?

a) Mammalian digestive system
   1) Parts leading to the small intestine - reduce feed particle size
      (a) Mouth - teeth grind feed; tongue moves pieces to throat
      (b) Esophagus - carries pieces
      (c) Stomach - stores food; begins digestion
   2) Small intestine
      (a) Duodenum - continues digestion
      (b) Remainder of small intestine - absorbs nutrients into the bloodstream
   3) Large intestine - absorbs water and molds indigestible feed wastes into solid form
      (a) Cecum - contains microorganisms; functions differently depending on the species, with the enlarged cecum in horses and rabbits allowing microorganisms to ferment roughage and break it down for absorption into the blood
      (b) Colon - absorbs water and forms the feces
   4) Parts allowing the exit of the feces
      (a) Anus - passes solid wastes out of the body
      (b) Rectum - carries the feces to the anus
b) Fowl digestive system
   1) Beak - breaks feed down for swallowing
   2) Gullet - passes feed to crop
   3) Crop - stores feed; softens feed for digestion
   4) Glandular stomach - begins digestion
   5) Gizzard - feed ground by muscular contractions
   6) Small intestine - digests and absorbs feed
   7) Ceca - contain bacteria; little role in digestion
   8) Large intestine - carries wastes to cloaca
   9) Cloaca - junction of reproductive and digestive systems
   10) Vent - allows wastes to exit the body

4. Ask students what digestion is. Describe the roles of enzymes and digestive juices in digestion. Use TM 1.7 to illustrate how digestive juices and enzymes work in a digestive system.

What are the roles of digestive juices and enzymes in the digestion of nutrients?

a) Digestive juices - fluids secreted into the digestive system from glands or tissue; enzymes - substances in the digestive juices that speed up the chemical reactions of digestion
b) Mammalian digestive system

1) Saliva - lubricates feed for passage into the digestive system; contains the enzyme amylase, which breaks down starches into sugars
2) Gastric juices
   (a) Diluted hydrochloric acid (HCl) - stops the action of amylase
   (b) Gastrin - stimulates the stomach to produce more gastric juices
   (c) Pepsin - enzyme that begins digestion of proteins
   (d) Rennin - enzyme that curdles a protein in milk
   (e) Gastric lipase - enzyme that begins the breakdown of fats
   (f) Mucus - protects the stomach lining from the acidic environment
3) Bile - helps to liquefy fats for absorption
4) Pancreatic juices
   (a) Pancreatic lipase - breaks fats down further, aided by bile
   (b) Trypsin - breaks down proteins
   (c) Chymotrypsin - acts on proteins
   (d) Amylase - continues to work on starch
5) Intestinal juices - contain the enzyme peptidase to break down proteins and the enzymes maltase, sucrase, and lactase to work on sugars and starches

c) Fowl digestive system
1) Saliva - softens feed for digestion in conjunction with secretions from the crop wall
2) Gastric juices - contain HCl and pepsin; pepsin begins digestion of proteins
3) Bile - liquefies fats
4) Pancreatic juices - include amylase, trypsin, and lipase; functions the same as the mammalian system
5) Intestinal juices - juices and enzymes function the same as the mammalian system

F. Other Activities

G. Conclusion

The most distinctive part of the monogastric digestive system is that it has a simple stomach with only one compartment. Digestion is carried out by digestive juices that include enzymes to convert feed into usable nutrients. Swine, horses, dogs, and rabbits have a monogastric digestive system, as do fowl, although the digestive system found in fowl has some significant differences from the other species.

H. Answers to Activity Sheets

AS 1.1

1. Gall bladder
2. Colon
3. Stomach
4. Liver
5. Rectum
6. Anus
7. Mouth
8. Esophagus
9. Cecum
10. Pancreas
11. Small intestine
12. Duodenum

AS 1.2

1. The monogastric digestive system is a simple digestive system in which the stomach has only one compartment.

2. Small intestine

3. Feed moves from the mouth to the stomach through the esophagus. From the stomach, it moves through the duodenum and the rest of the small intestine and then into the large intestine, through the cecum, colon, and rectum. Wastes exit the body through the anus.

I. Answers to Evaluation

1. Stomach
2. Colon
3. Rectum
4. Mouth
5. Esophagus
6. Anus
7. Cecum
8. Small intestine
9. Duodenum
10. d
11. c
12. a
13. b
14. d
15. b
16. a
17. c
18. a

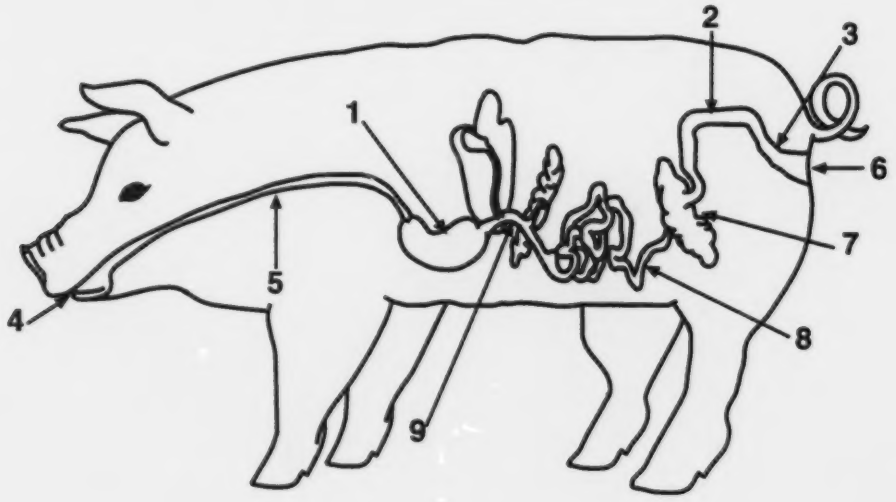
19. Once the feed enters the digestive system through the beak, it passes through the gullet to the crop. It then enters the glandular stomach, followed by the gizzard. From the gizzard it moves through the small intestine, passes by the ceca, and enters the large intestine. It passes out of the body through the cloaca and vent.

UNIT - INTRODUCTION TO ANIMAL NUTRITION Name_____

Lesson 1: Monogastric Digestive System Date_____

EVALUATION

From the diagram on the right, identify the parts of the digestive system of swine and write the name of the part in the corresponding numbered blank.



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____

Circle the letter that corresponds to the best answer.

10. What digestive part stores feed in fowl?

    a. Esophagus
    b. Beak
    c. Small intestine
    d. Crop

11. What part absorbs digestible nutrients into the bloodstream?

    a. Esophagus
    b. Large intestine
    c. Small intestine
    d. Stomach

18

12. What digestive part serves as an outlet from the body for feces?

a. Anus
b. Cecum
c. Colon
d. Small intestine

13. Which species does not use teeth to break feed into small particles?

a. Dogs
b. Fowl
c. Horses
d. Swine

14. Gastric juices contain the enzymes _____ and gastrin.

a. Amylase
b. Trypsin
c. Maltase
d. Pepsin

15. Where is bile produced to help neutralize acidity in the digestive system?

a. Duodenum
b. Liver
c. Mouth
d. Pancreas

16. Which enzyme works on starch?

a. Amylase
b. Lipase
c. Peptide
d. Trypsin

17. Which species uses the cecum to ferment feed?

a. Dogs
b. Fowl
c. Horses
d. Swine

18. The ceca are found in which species?

a. Fowl
b. Horses
c. Rabbits
d. Swine

Complete the following short answer question.

19. What is the path taken by feed as it passes through the digestive system of the fowl? Describe the path.

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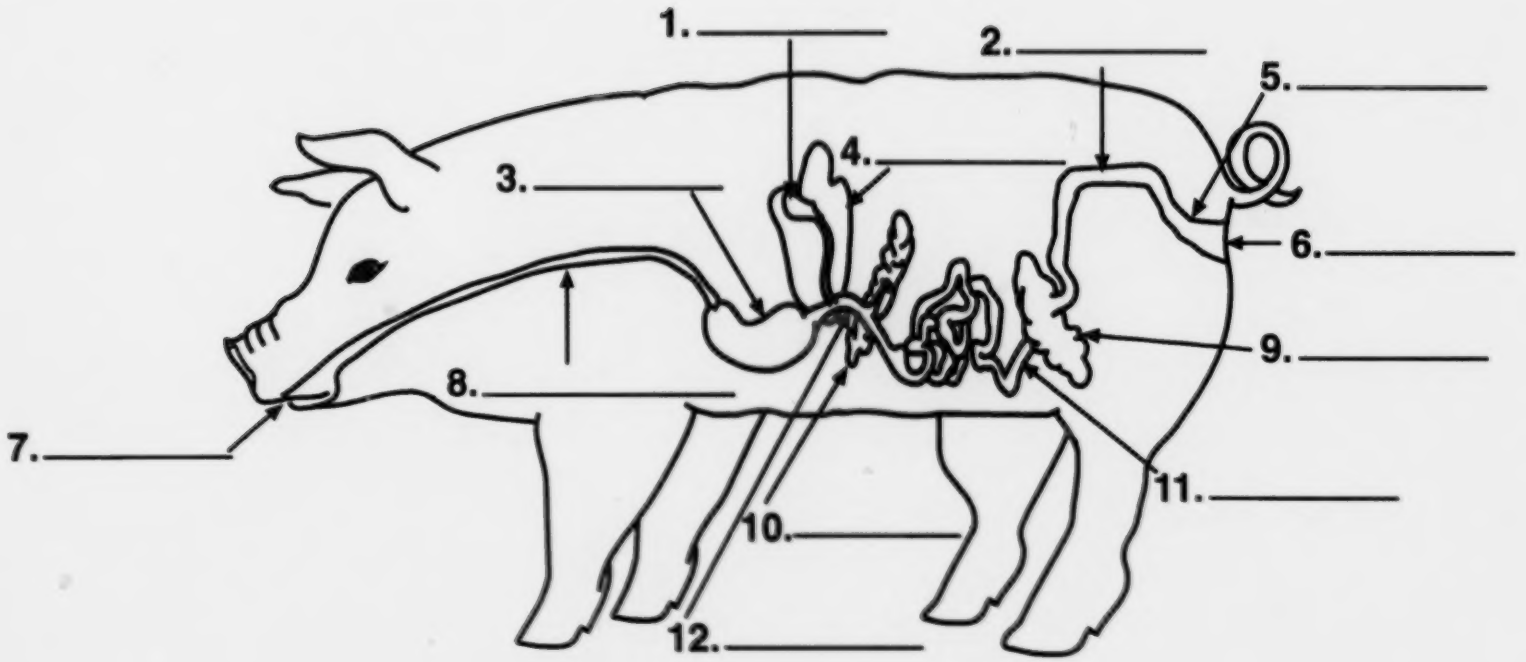
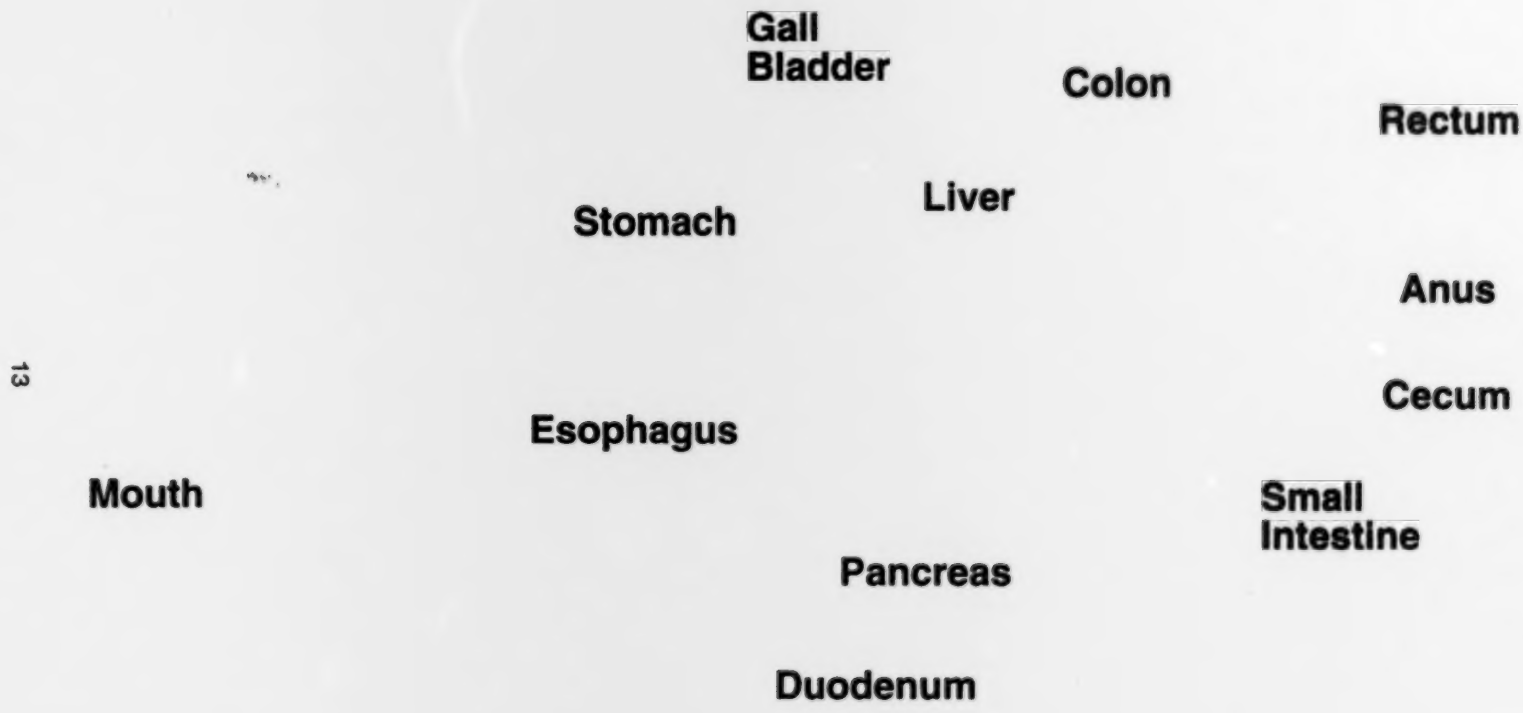
Swine Digestive System

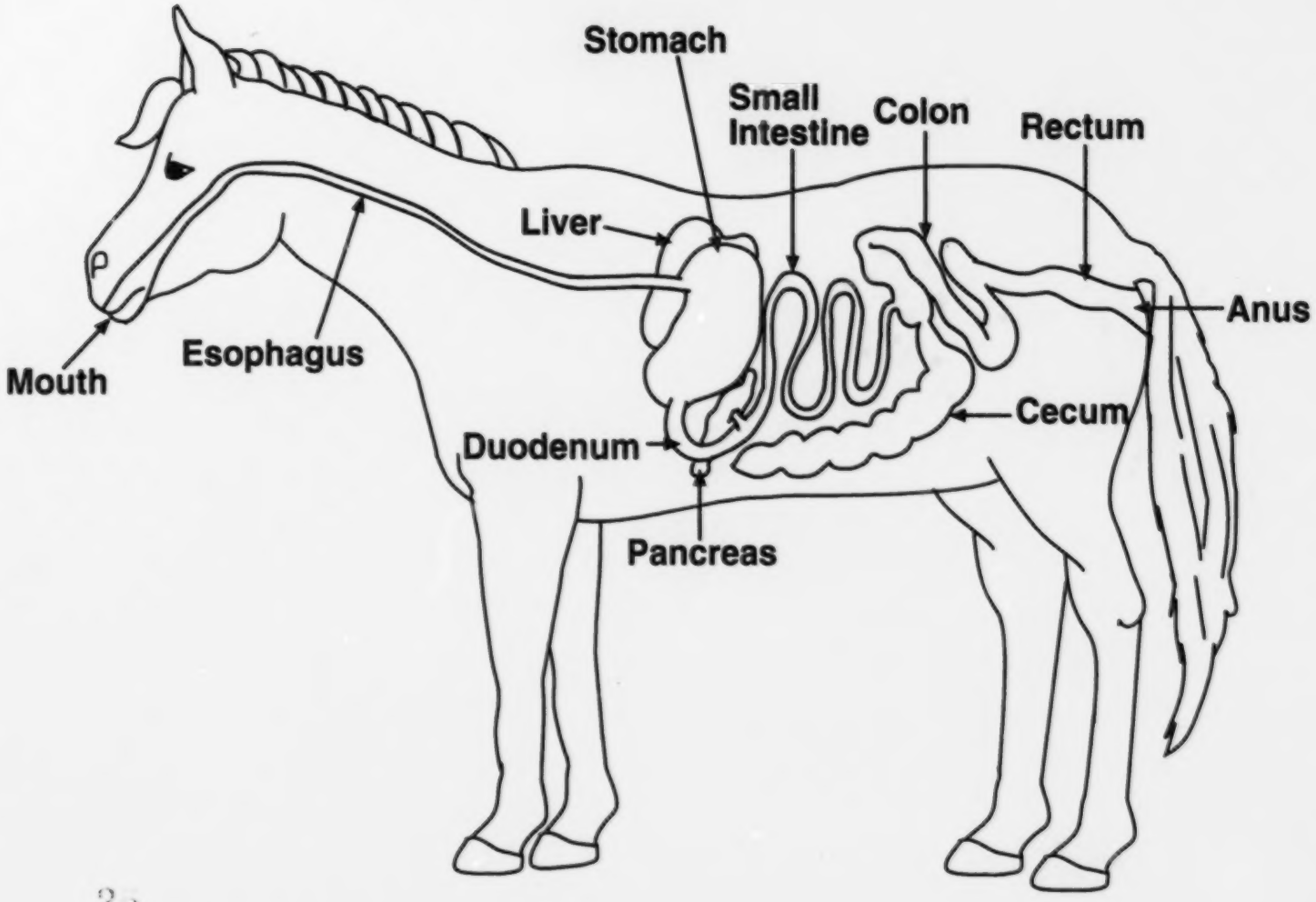


TM 1.1

Swine Digestive System (Overlay)



Horse Digestive System



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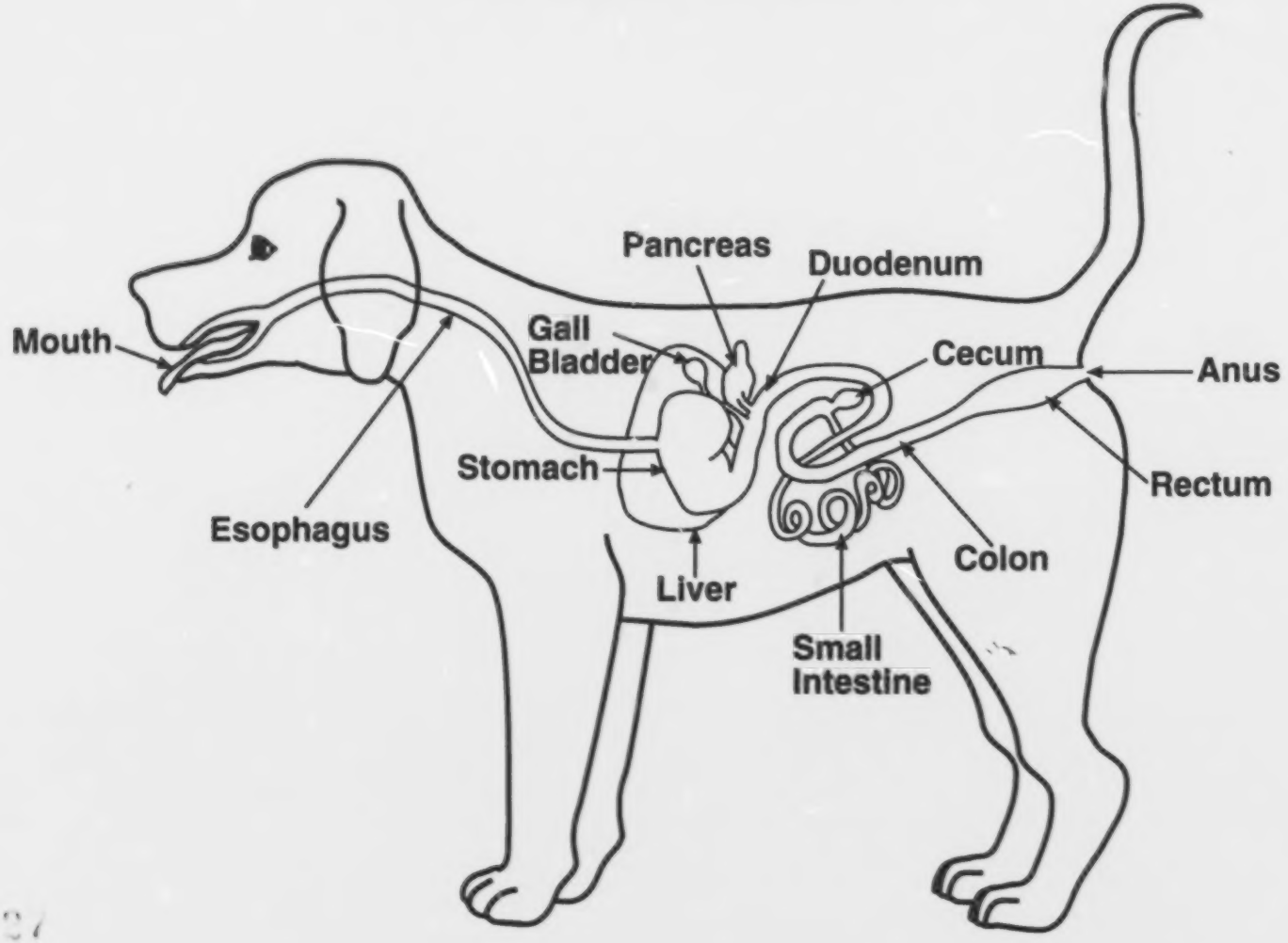
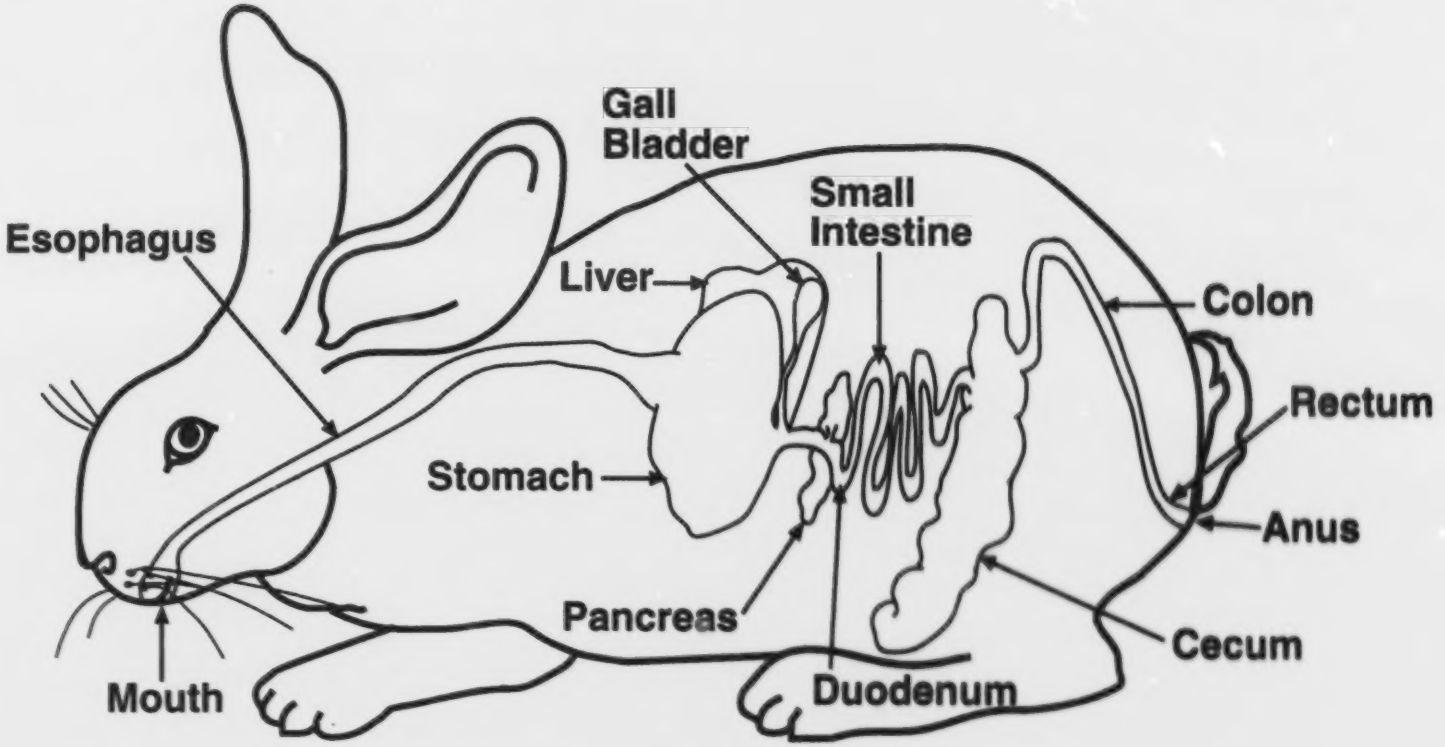
TM 1.3

Dog Digestive System

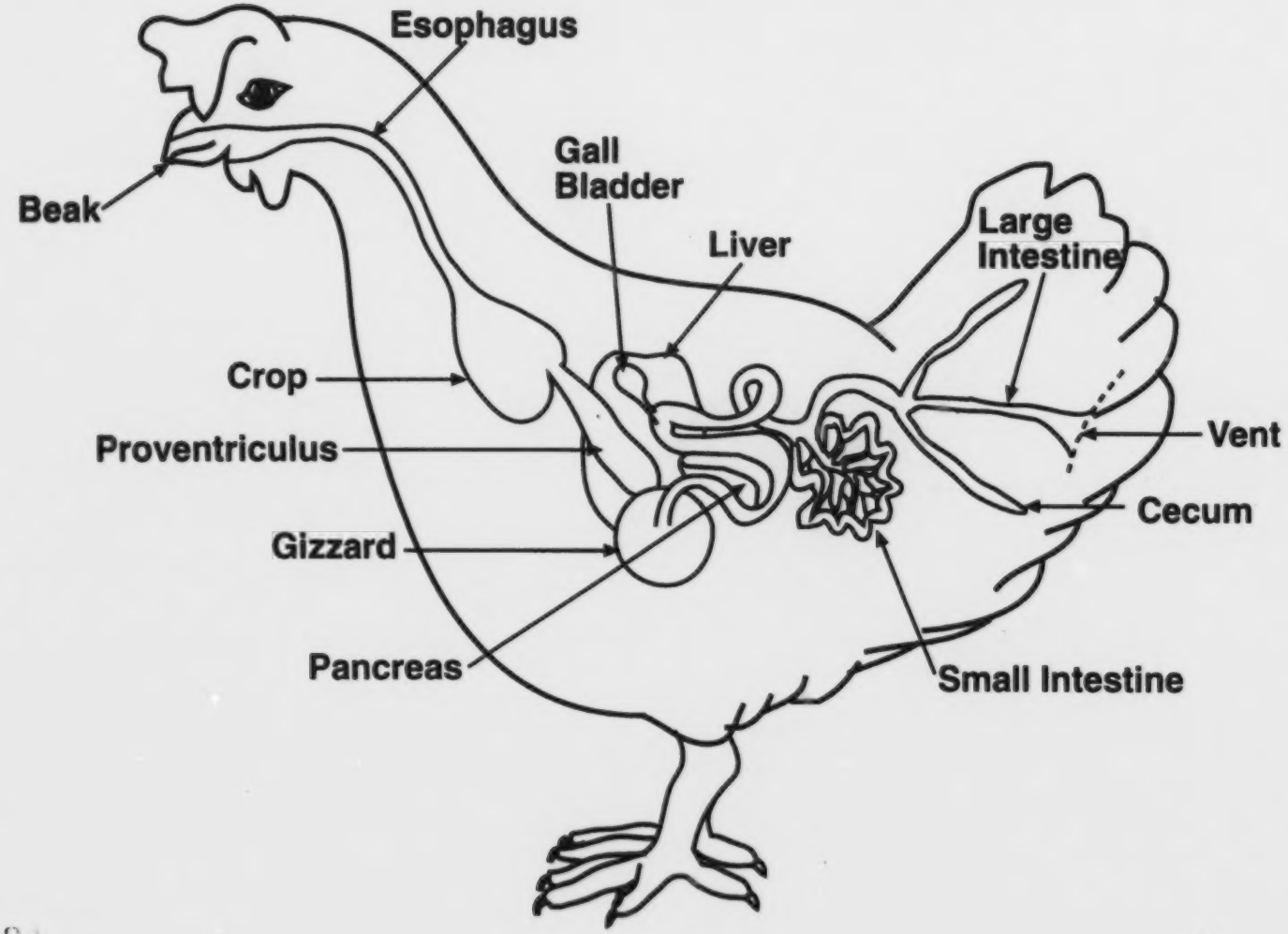


TM 1.4

Rabbit Digestive System



Fowl Digestive System - Chicken



TM 1.6

Enzymes in the Monogastric Digestive System

Digestive Juice	Enzyme	Food Component	Source/Location
Saliva	Amylase	Starch	Mouth
Gastric	Pepsin	Protein	Stomach
	Rennin	Protein (in milk)	
	Lipase	Fat	
Pancreatic	Lipase	Fat	Duodenum
	Trypsin	Protein	
	Chymotrypsin	Protein	
	Amylase	Starch	
Bile	-------	Fat	Duodenum
Intestinal	Peptidase	Protein	Small intestine
	Maltase	Starch/Sugar	
	Sucrase	Starch/Sugar	
	Lactase	Starch/Sugar	

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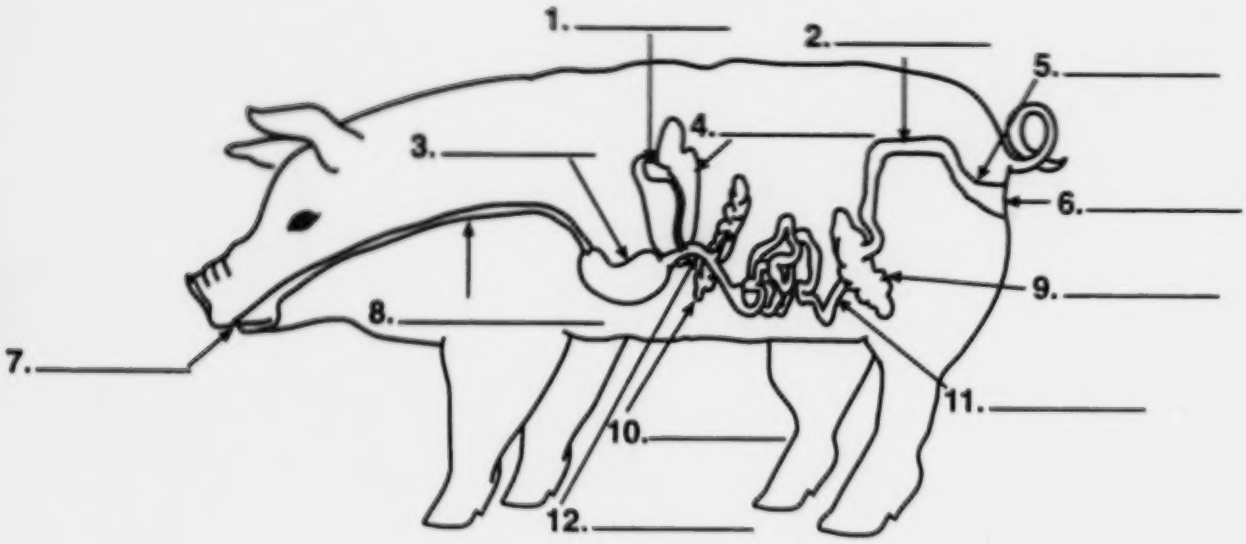
Lesson 1: Monogastric Digestive System Name_____

Swine Digestive System

Objective: Identify the parts of the monogastric digestive system of swine.

Label the parts of the monogastric digestive system.



Lesson 1: Monogastric Digestive System Name_____

Dissection of the Monogastric Digestive System

Objective: Identify, locate, and describe the parts and function of the monogastric digestive system.

Activity Length: 1 hour

Materials and Equipment:

Lab coat
Lab gloves (palpation sleeves)
Swine digestive system
Dissecting knife

Procedure:

1. After putting on the lab coat and gloves, locate the esophagus and cut between the esophagus and the stomach. Set the esophagus to the side.
2. Find the point where the stomach attaches to the small intestine at the duodenum and separate the two with the knife.
3. Cut open the stomach and examine the interior of the stomach.
4. Locate the place where the small intestine and large intestine join. Separate the small intestine from the large intestine.
5. Look at the small intestine. Identify the duodenum and the rest of the small intestine and cut between the two.
6. Detach the large intestine from the rectum.
7. Sever the cecum and the colon.
8. Separate the rectum and the anus.

Key Questions:

1. What is the monogastric digestive system?

2. What part absorbs the nutrients into the body?

3. What is the path taken by feed through the digestive system?

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 2: Ruminant Digestive System

Competency/Objective: Describe the parts and functions of the ruminant digestive system.

Study Questions

1. **What livestock species have a ruminant digestive system?**
2. **What are the main parts of the ruminant digestive system?**
3. **What are the functions of the main parts of the ruminant digestive system?**
4. **How does a ruminant convert feed nutrients into usable nutrients?**
5. **Why are ruminants better able to utilize forages?**

References

1. *Introduction to Animal Nutrition (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1996.
2. Transparency Masters
   a) TM 2.1a: Digestive System of Cattle
   b) TM 2.1b: Digestive System of Cattle
   c) TM 2.2: Digestive System of Cattle (Overlay)
   d) TM 2.3: Digestive System of Sheep
   e) TM 2.4: Ruminant Stomach Compartments
   f) TM 2.5: Three Possible Routes of Feed in Ruminants
3. Activity Sheets
   a) AS 2.1: Digestive System of Cattle
   b) AS 2.2: Ruminant Digestive System
   c) AS 2.3: Monogastric and Ruminant Digestive Systems (Instructor)

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 2: Ruminant Digestive System

TEACHING PROCEDURES

A. Review

The last lesson covered the parts and functions of the monogastric digestive system. It described how feed is broken down into usable nutrients in the system in swine, horses, rabbits, dogs, and fowl. This lesson is about the ruminant digestive system and how it functions in the digestion of grain and forage.

B. Motivation

Display a beef product like a steak along with a piece of hay or some grass. Ask students which one they would prefer to eat. Have the students explain how the ruminant digestive system works to produce steak from forages.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask which livestock species have a ruminant digestive system.

What livestock species have a ruminant digestive system?

a) Cattle
b) Sheep

2. Ask what the parts of the ruminant digestive system are. Point out the importance of the related organs--the liver, gall bladder, and pancreas--in digestion. Hand out AS 2.1 and have the students fill in the names of the parts during the discussion. Use TM 2.1a to illustrate the stomach and TM 2.1b as an overlay to show the rest of the system. (An overlay with labels for the parts of the system is included in TM 2.2.) Display TM 2.3 to illustrate the digestive system of sheep.

What are the main parts of the ruminant digestive system?

a) Mouth
b) Esophagus
c) Four stomach compartments
    1) Rumen
    2) Reticulum
    3) Omasum
    4) Abomasum
d) Small Intestine
    1) Duodenum
    2) Remainder of small intestine
e) Large intestine
    1) Cecum
    2) Colon

3) Rectum

f) Anus

3. Ask what the functions of the main parts are. Discuss the functions.

What are the functions of the main parts of the ruminant digestive system?

a) Mouth - allows feed to enter the digestive system
   1) Tongue - in cattle, grabs grass and other feeds to bring them into the mouth; moves feeds to the throat
   2) Teeth - bottom teeth cut grass against top dental pad; back upper and lower teeth chew cud and other feeds
b) Esophagus - transports feed back and forth from the mouth to the stomach
c) Stomach compartments
   1) Rumen (paunch) - helps break feed down
   2) Reticulum (honeycomb) - forces roughage back to the mouth for rumination and further breaks down the feed
   3) Omasum (many piles) - absorbs some water and nutrients
   4) Abomasum (true stomach) - similar to the monogastric stomach; site where digestive juices with acids and enzymes are added, moisture increases, and protein is partially digested
d) Small intestine
   1) Duodenum - continues digestive process
   2) Remainder of small intestine - absorbs digested nutrients into the bloodstream
e) Large intestine
   1) Cecum - plays a minor role in the breakdown of roughage
   2) Colon - absorbs water and forms wastes into feces; also absorbs some nutrients
   3) Rectum - stores feces before elimination
f) Anus - the opening through which undigestible solid wastes exit from the body

4. Ask how a ruminant is able to convert feed into nutrients. Use TM 2.4 when describing the ruminant stomach.

How does a ruminant convert feed nutrients into usable nutrients?

a) The rumen and reticulum have microorganisms that help break down feed.
   1) Bacteria break down the sugars and starches in feed concentrates and young forages and ferment fiber feed parts.
   2) Protozoa aid in the storage of available sugars and starches as well as forming some protein and fermenting fiber.
   3) Fungi play an unclear role in fiber digestion.
b) In the rumen, sugar, starches, and fiber are converted into fatty acids.
c) Fatty acids are absorbed in the omasum.
d) Other nutrients are broken down by the digestive juices and enzymes in the abomasum.
e) The breakdown of nutrients in the abomasum and the small intestine is similar to the monogastric digestive system.

5. Ask what parts of the ruminant digestive system enable it to digest forages efficiently. Discuss why ruminants are better able to utilize forages. Use TM 2.5 to illustrate the process. Compare the routes of ground concentrates and forages.

Why are ruminants better able to utilize forages?

a) The rumen has microorganisms to help break down forages.

b) Forages move from the rumen to the reticulum.
c) If forages need to be broken down more, the reticulum pumps the cud up to the mouth to be chewed.
d) When swallowed, the cud enters the reticulum and then passes to the omasum and abomasum.

F. Other Activities

1. Perform a dissection of a ruminant digestive system. Contact a processing plant to obtain a digestive system. Keep it frozen until the dissection is performed.

2. If possible, take students on a field trip to see a fistulated cow.

G. Conclusion

Unlike the monogastric digestive system, the ruminant digestive system found in cattle and sheep includes four compartments. These compartments utilize forages efficiently, converting them into usable nutrients for the animal.

H. Answers to Activity Sheets

AS 2.1

1. Esophagus
2. Mouth
3. Reticulum
4. Rumen
5. Omasum
6. Abomasum
7. Gall bladder
8. Liver
9. Pancreas
10. Rectum
11. Anus
12. Colon
13. Cecum
14. Small intestine
15. Duodenum

AS 2.2

1. Rumen, reticulum, omasum, abomasum
2. Abomasum
3. Hay enters the mouth and passes through the esophagus and reticulum and into the rumen. The hay next enters the reticulum again, and if it is not fully broken down, it is pumped back up through the esophagus to be chewed as cud. After chewing, the cud is swallowed and enters the reticulum. The hay then passes on to the omasum, abomasum, and small intestine. Finally, it passes through the large intestine and out of the body through the anus.

I. Answers to Evaluation

1. Esophagus
2. Rumen
3. Rectum

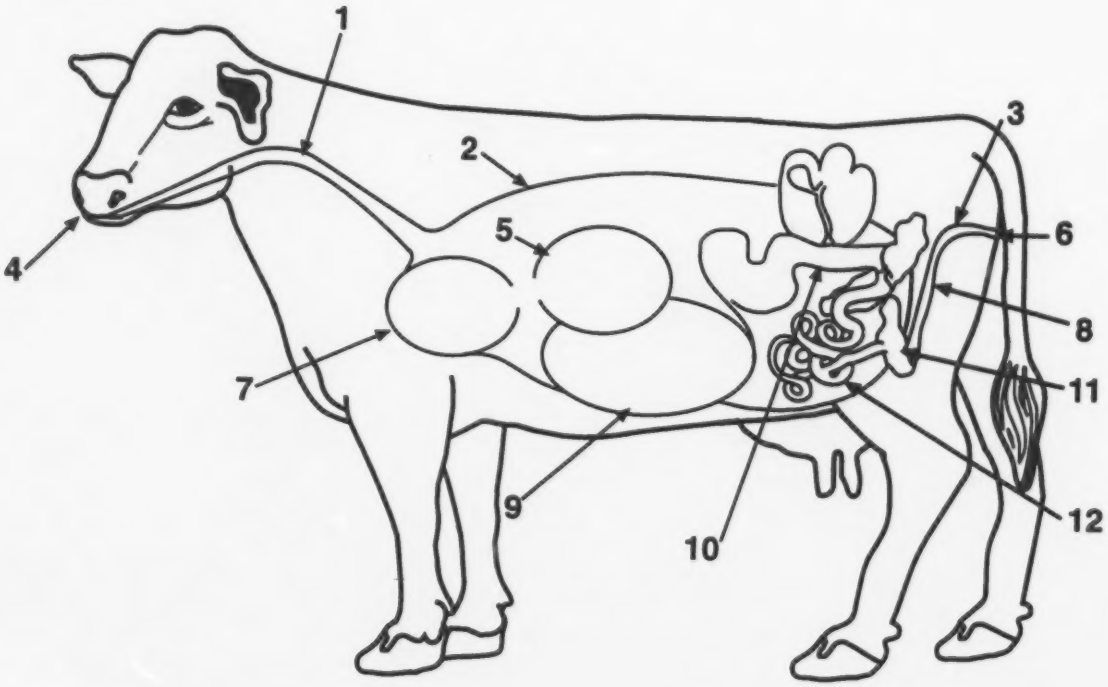
4. Mouth
5. Omasum
6. Anus
7. Reticulum
8. Colon
9. Abomasum
10. Duodenum
11. Cecum
12. Small intestine
13. c
14. b
15. a
16. b
17. d
18. Forages
19. Ground concentrate or cud

UNIT - INTRODUCTION TO ANIMAL NUTRITION Name_____

Lesson 2: Ruminant Digestive System Date_____

EVALUATION

From the following diagram, write the names of the parts of the ruminant digestive system in the corresponding numbered spaces.



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

Circle the letter that corresponds to the best answer.

13. Which part of the digestive system acts like a pump to force the cud back to the mouth?

    a. Abomasum
    b. Esophagus
    c. Reticulum
    d. Rumen

14. Which part absorbs water from the digested material?

    a. Esophagus
    b. Large intestine
    c. Rumen
    d. Small intestine

15. The _____ acts very similar to the monogastric stomach when converting feed into usable nutrients.

    a. Abomasum
    b. Omasum
    c. Reticulum
    d. Rumen

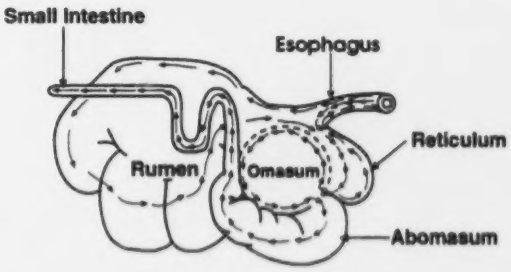
16. Which of the following helps the ruminant to break down forages?

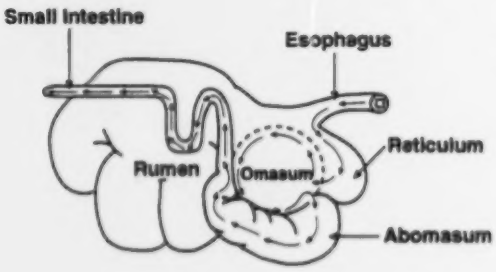
    a. Amylase
    b. Bacteria
    c. Hydrochloric acid
    d. Pepsin

17. Which two species have a ruminant digestive system?

    a. Sheep and horses
    b. Rabbits and sheep
    c. Horses and cattle
    d. Cattle and sheep

For each picture, name the type of feed that would be passed through the ruminant digestive system.

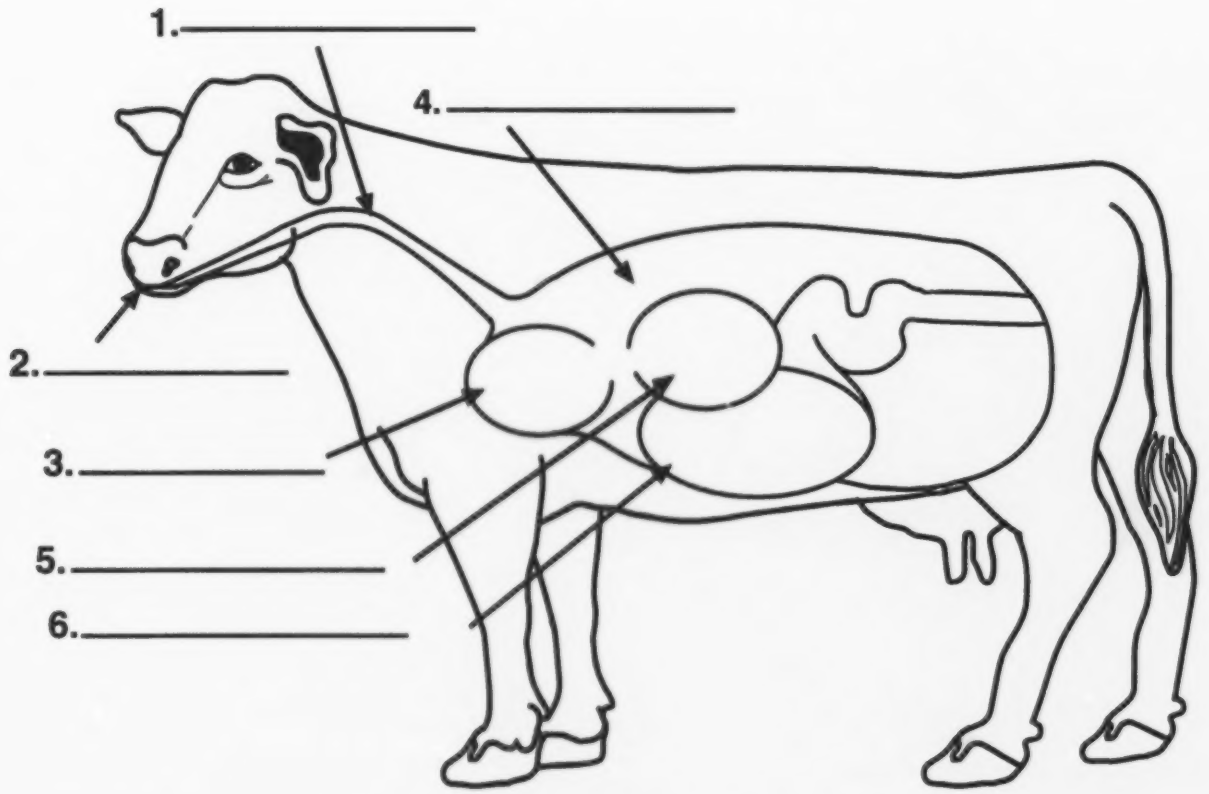




18. _____

19. _____

Digestive System of Cattle



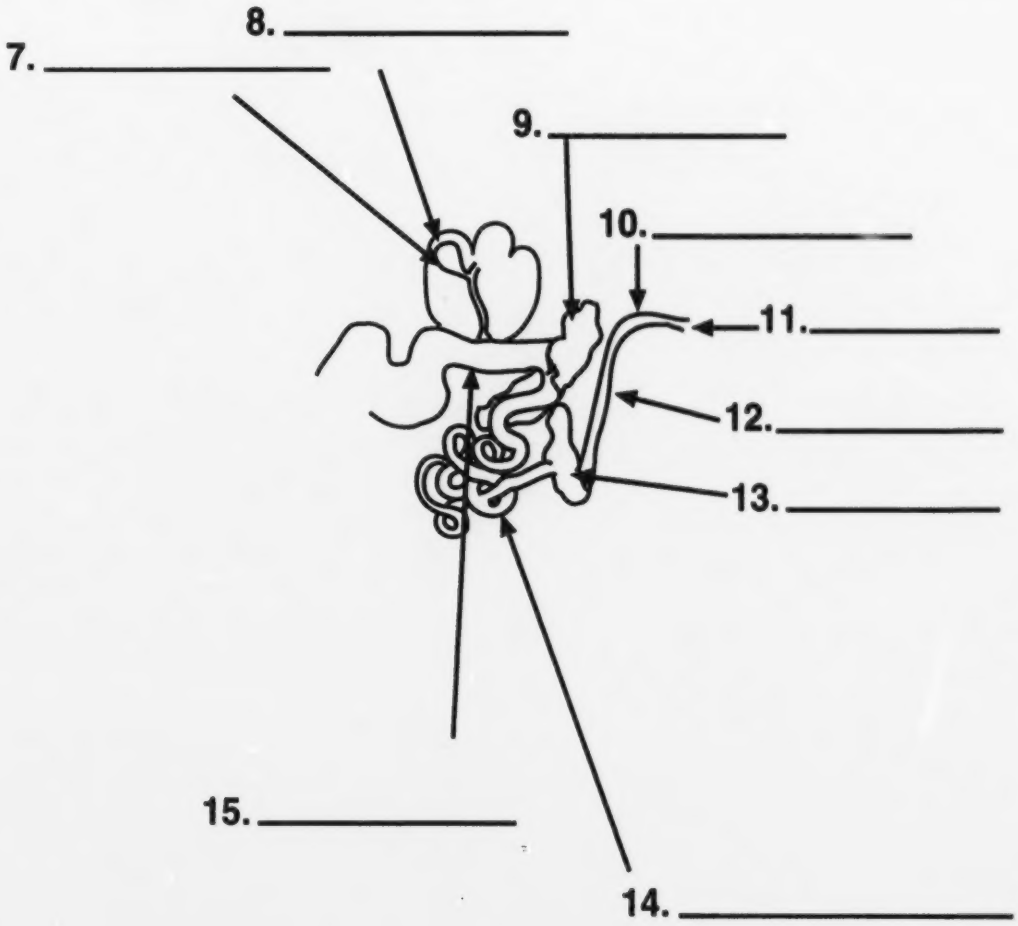
37

45

46

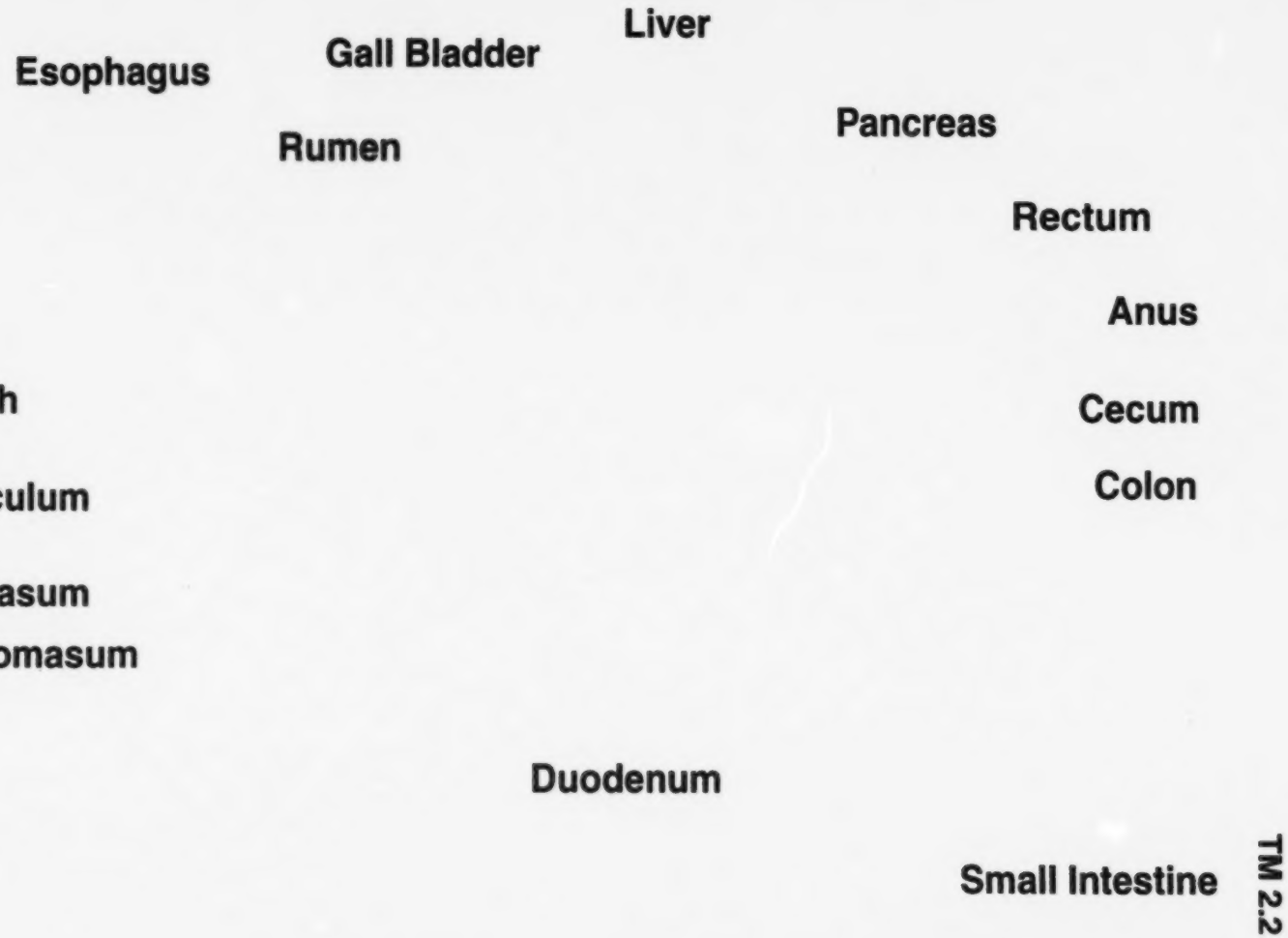
TM 2.1a

Digestive System of Cattle

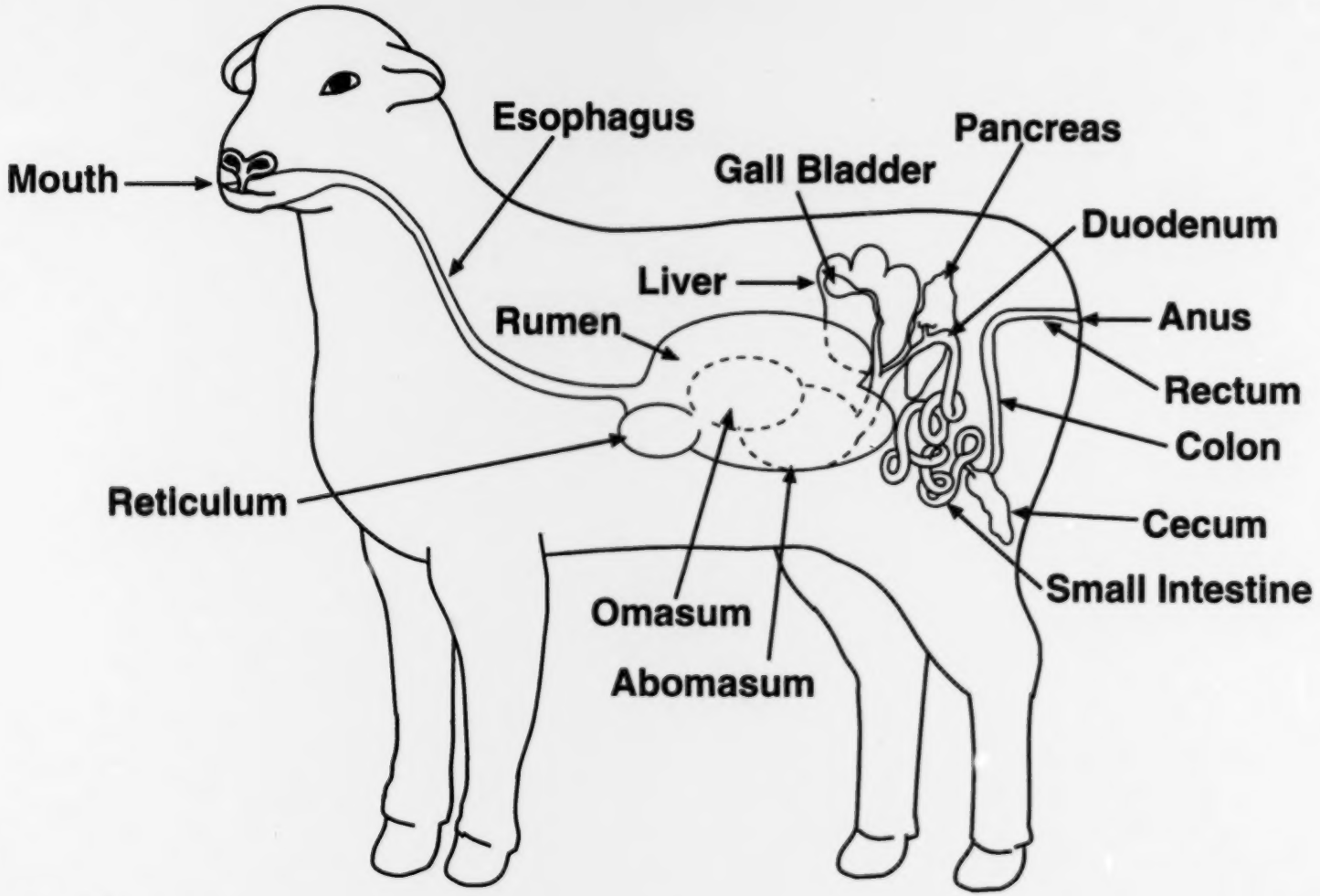


TM 2.1b

Digestive System of Cattle (Overlay)



Digestive System of Sheep



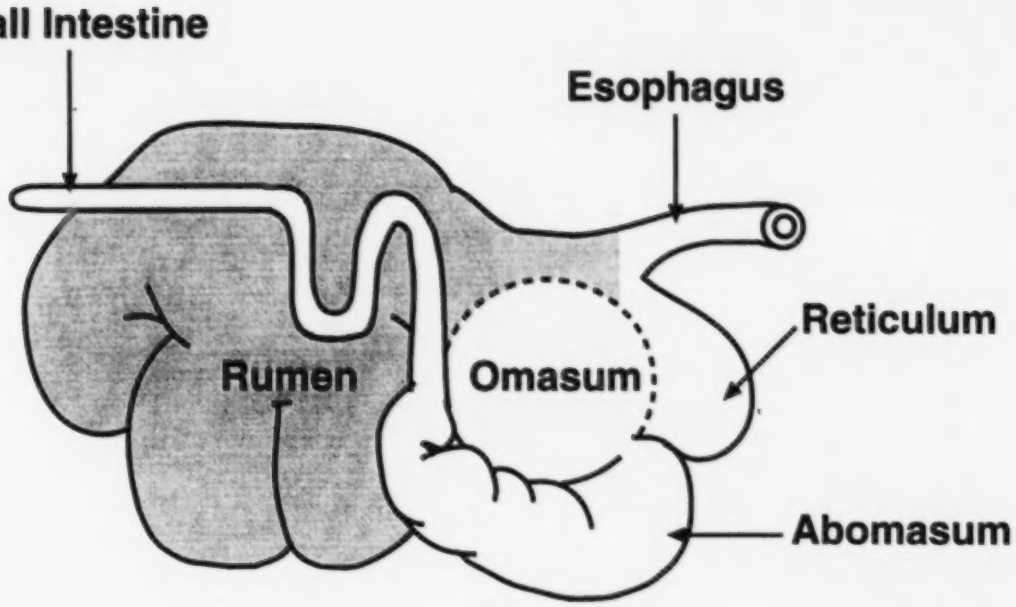
43

TM 2.3

51

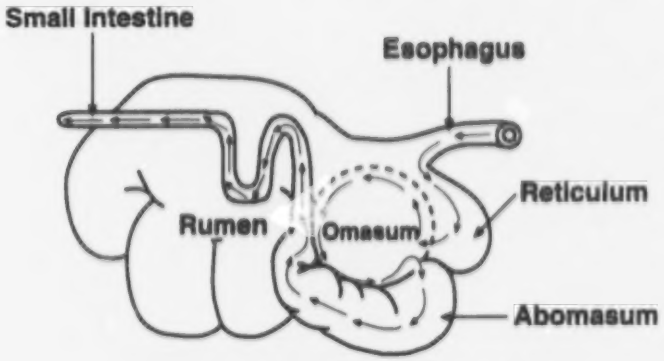
52

Ruminant Stomach Compartments

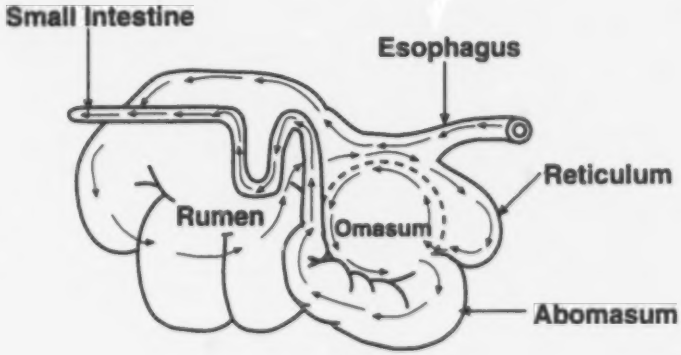


TM 2.4

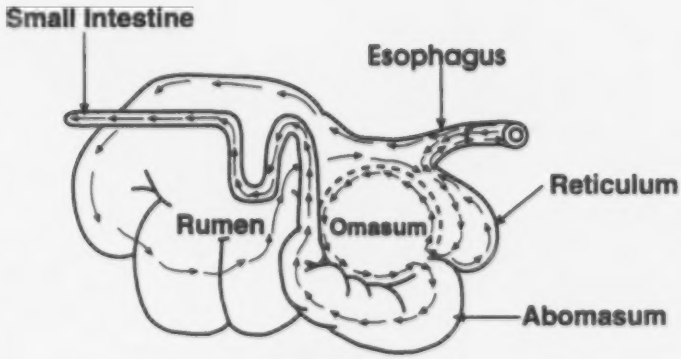
Three Possible Routes of Feed in Ruminants



Ground Concentrates or Cud



Light Grain



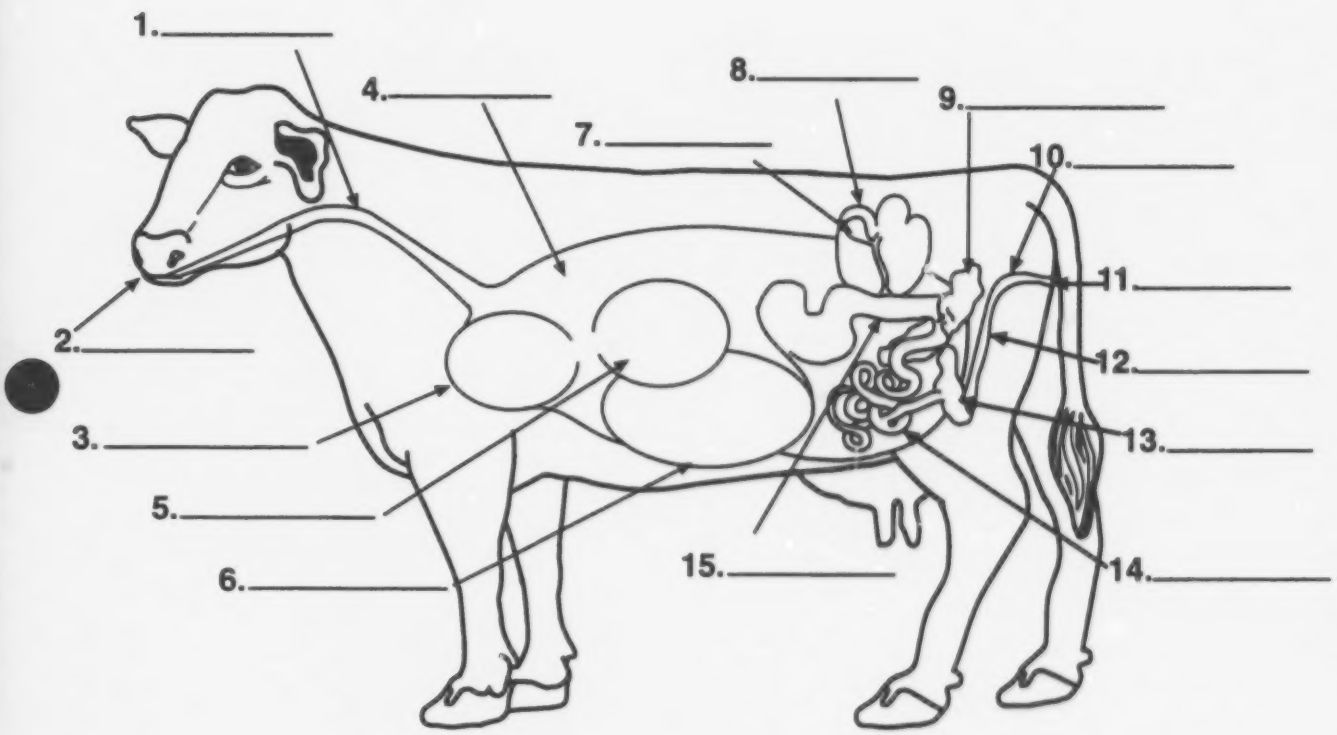
Forages

Lesson 2: Ruminant Digestive System Name_____

Digestive System of Cattle

Objective: Identify the parts of the ruminant digestive system in cattle.

Label the parts of the ruminant digestive system.



Lesson 2: Ruminant Digestive System Name_____

Ruminant Digestive System

Objective: Identify the parts of the ruminant digestive system and their functions.

Activity Length: 30 minutes

Procedure:

NOTE: Your instructor may have you work in groups.

1. Choose one of the following parts:

Mouth	Abomasum
Esophagus	Small intestine
Rumen	Large intestine
Reticulum	Anus
Omasum	

2. Research and write down the functions of each part. Students researching the esophagus should also be able to describe the path taken by grain in the digestive system, while those students researching the function of the anus should be able to describe the path taken by forages.

3. Line up in order starting with the mouth and ending with the anus. The person who is representing the mouth is responsible for ensuring the correct order.

4. After lining up, name the part and describe its functions based on your research.

5. The students who have researched the paths taken by grain and forages should describe them.

Key Questions:

1. What are the four compartments of the stomach?

2. What digestive part is known as the true stomach?

3. What is the path taken by hay as it passes through the ruminant digestive system?

Lesson 2: Ruminant Digestive System

Monogastric and Ruminant Digestive Systems

Objective: Illustrate the monogastric and ruminant digestive systems.

Activity Length: 45 minutes

Procedure:

NOTE: This activity may be used as an alternative to instructor lecture to teach the structure and function of the monogastric and ruminant digestive systems.

1. Divide the class into groups of two or three students.
2. Have one student from each group draw a folded slip of paper from a container to determine what species each group will draw.
3. Have each group draw the outline of the animal and its digestive system.
4. The parts of the digestive system should be labeled.
5. After all the groups have completed their drawings, have the members of each group do a presentation in which they describe each of the parts of the digestive system and its function to the class.

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 3: The Importance of Meeting Nutritional Needs

Competency/Objective: Identify the importance of meeting the nutritional needs of animals.

Study Questions

1. **What are nutrients?**

2. **What are the six basic nutrients and their functions?**

3. **Why is meeting the nutritional needs of the animal important?**

References

1. *Introduction to Animal Nutrition (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1996.

2. Transparency Masters

   a) TM 3.1: Nutrient Requirements for a Cow through Life Stages

3. Activity Sheet

   a) AS 3.1: Nutrient Recommendations (Instructor)
   b) AS 3.2: Nutrient Recommendations (Student)

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 3: The Importance of Meeting Nutritional Needs

TEACHING PROCEDURES

A. Review

The previous two lessons covered the two types of digestive systems, monogastric and ruminant. In each system, feed is converted into nutrients. In this lesson, the various nutrients that are needed to maintain an animal will be discussed.

B. Motivation

Read the case study in AS 3.1 out loud. Ask students what they need to know to help Brandon solve his problem. After some discussion, lead students through study questions 1 and 2.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask the students what a nutrient is. Discuss the definition of nutrients and where they originate.

   NOTE: AS 3.1 may be used as an alternative format to teach study questions 1 and 2, or it can be completed after the discussion of these questions.

   What are nutrients?

   a) Elements or chemical compounds that support the life processes of an animal
   b) Allow animals to maintain bodily functions by entering cells of the body and fueling their growth and function
   c) Found in water, grain, roughage, and other food substances taken into the digestive system through the mouth

2. Ask what the six basic nutrients are. Describe the nutrients and their functions.

   What are the six basic nutrients and their functions?

   a) Water - contains hydrogen and oxygen
      1) Plays a role in biochemical reactions including respiration, digestion, and assimilation
      2) Transports nutrients
      3) Transports wastes
      4) Regulates body temperature
      5) Gives the body its form
   b) Proteins - contain carbon, hydrogen, oxygen, and nitrogen; may contain iron, phosphorus, and sulfur
      1) Develop and repair body organs and tissues like muscles, nerves, skin, hair, hooves, and feathers
      2) Used to produce milk, wool, and eggs
      3) Develop the fetus

4) Generate some enzymes and hormones
5) Form a part of DNA

c) Carbohydrates (sugar, starch, and fiber) - contain carbon, hydrogen, and oxygen
1) Provide energy that powers muscle movement required for exercise and essential functions such as breathing, digestion, and beating of heart
2) Produce body heat
3) Stored as body fat

d) Fats - contain carbon, nitrogen, and oxygen
1) Function as a valuable energy source
2) Provide body heat
3) Carry some vitamins

e) Minerals - inorganic elements
1) Supply materials for building skeleton and teeth
2) Form a part of body regulators such as enzymes and hormones

f) Vitamins - organic substances that are fat- or water-soluble
1) Regulate the digestion, absorption, and metabolism of nutrients
2) Regulate the formation of new cells
3) Regulate development of vision, bones, hair, feathers, skin, and muscles
4) Help protect against diseases
5) Develop and maintain the nervous system

3. Ask students why animals might have different nutrient requirements at different times. Discuss the differences in nutrient requirements. Use TM 3.1 to illustrate the requirements.

Why is meeting the nutritional needs of the animal important?

a) Maintenance
1) Must be met before any other nutrient needs are considered
2) Keep the body functioning with no weight gain or loss and no production
3) Amount of feed needed to maintain the animal depends on body size

b) Lactation
1) Fats and carbohydrates - supply energy vital for lactation
2) Protein
3) Water
4) Minerals - calcium and phosphorus needed during lactation
5) Vitamins - A, B-complex, and D (if indoors) are needed when female is lactating

c) Conception and gestation
1) Ensures good fetal growth, particularly for increased nutrient needs of fetus in the last trimester for growth
2) Needed because female requires additional nutrients to maintain itself and fetus

d) Growth and development
1) Fats and carbohydrates - supply energy source
2) Protein - builds muscles and produces bone and connective tissues
3) Minerals - requires calcium and phosphorus for bone growth
4) Vitamins - requires higher quantities, especially D

e) Health - nutrients needed to carry out vital bodily functions; animal must be healthy to be most productive

F. Other Activities

Show students pictures of animals suffering from nutrient deficiencies to familiarize them with the effects of deficiencies.

G. Conclusion

Nutrients are elements or chemical compounds that support the life processes of the animal. There are six basic nutrients -- water, protein, carbohydrates, fats, vitamins, and minerals. Each nutrient has a specific function and may be important for health and maintenance, conception/gestation, lactation, and growth/development.

H. Answers to Activity Sheets

See the following page.

Effect-Cause
Problem-Solving Technique

Define the problem:

What is causing the cows to be open and very thin?

Possible Causes	Related Facts	Accept/ Reject Cause
Water deficiency	**Components**: Hydrogen and oxygen **Functions**: Plays a role in biochemical reactions including respiration, digestion, and assimilation. Transports nutrients. Maintains body temperature. Gives body its form and carries body waste.	Reject
Protein deficiency	**Components**: Essential and non-essential amino acids containing carbon, hydrogen, oxygen, and nitrogen. Sometimes include iron, phosphorus and sulfur. **Functions**: Develops and repairs body organs and tissues like muscles, nerves, skin, hair, hooves, and feathers. Produces milk, wool, and eggs. Develops the fetus and generates enzymes and hormones. Forms a part of DNA.	Reject
Carbohydrate deficiency	**Components:** Carbon, hydrogen, and oxygen in sugars, starches, and fiber **Functions**: Provides energy for bodily functions like breathing, digestion, and exercise. Produces body heat. Stored as body fat.	Accept
Fat deficiency	**Components**: Same as carbohydrates but supplies 2.25 times more energy. **Functions**: Serves as an energy source. Provides body heat. Carries some vitamins.	Reject
Mineral deficiency	**Components**: Inorganic elements that are macro- or micro-minerals. Macro-minerals are Ca, P, Na, K, Cl, Mg, and S. Micro-minerals are Fe, I, Cu, Co, Fl, Mn, Zn, Mo, and Se. **Functions**: Supply materials for building skeleton and teeth. Form a part of body regulators such as enzymes and hormones.	Reject

	Effect-Cause Problem-Solving Technique	
Possible Causes	**Related Facts**	**Accept/ Reject Cause**
Vitamin deficiency	**Components**: Organic substances that are either fat- or water-soluble. Fat-soluble vitamins are A, D, E and K, and water-soluble vitamins are C and B-complex. **Functions**: Regulate digestion, absorption, and metabolism of nutrients. Regulate the development of vision, bone, hair, feathers, skin, and muscles. Regulate the formation of new cells, protect against diseases, and develop and maintain the nervous system.	Reject
Decision/Recommendation: A carbohydrate deficiency is the cause of the problem. Brandon's family should increase carbohydrate levels in the feed ration.		

I. Answers to Evaluation

1. c
2. d
3. a
4. d
5. d
6. c
7. a
8. b
9. d
10. b

11. During gestation the female needs nutrients to maintain itself and the fetus. The last trimester requires the most nutrients since it is a period of great growth. The additional nutritional requirements for the female are equal to those of the young animal after birth. During lactation, the female needs protein, vitamins, minerals, fats, and carbohydrates. Protein and fats and carbohydrates are vital for producing milk. Minerals needed are calcium and phosphorus. Vitamins A and B-complex are also needed, along with vitamin D (if indoors).

12. Nutrients are important for animal health because they are needed to carry out vital bodily functions. An animal must be healthy in order to be at its most productive.

UNIT - INTRODUCTION TO ANIMAL NUTRITION Name_____

Lesson 3: The Importance of Meeting Nutritional Needs Date_____

EVALUATION

Circle the letter that corresponds to the best answer.

1. What are elements or chemical compounds that support life processes called?

   a. Feed
   b. Grass
   c. Nutrient
   d. Roughage

2. Which nutrient is composed of hydrogen and oxygen and maintains body temperature?

   a. Carbohydrates
   b. Fat
   c. Mineral
   d. Water

3. Which two nutrients are used for energy?

   a. Fats and carbohydrates
   b. Fats and protein
   c. Protein and minerals
   d. Vitamins and carbohydrates

4. Which of the following is a carbohydrate?

   a. Calcium
   b. Amino acids
   c. Fatty acids
   d. Sugar

5. If a cow cannot see properly, in which nutrient may the cow be deficient?

   a. Fat
   b. Minerals
   c. Protein
   d. Vitamins

6. Which nutrient develops and repairs body organs and tissues?

   a. Carbohydrates
   b. Minerals
   c. Protein
   d. Vitamins

7. Which of the following are macro-minerals?

   a. Calcium and potassium
   b. Chlorine and copper
   c. Cobalt and phosphorus
   d. Iodine and zinc

8. Fats have the same components as carbohydrates but provide _____ times more energy.

   a. 2.00
   b. 2.25
   c. 2.50
   d. 2.75

9. When are nutrients needed to sustain body functions with no weight gain or loss?

   a. Gestation
   b. Growth and development
   c. Health and maintenance
   d. Maintenance

10. When are additional nutrients needed for building muscles, bone, and connective tissue?

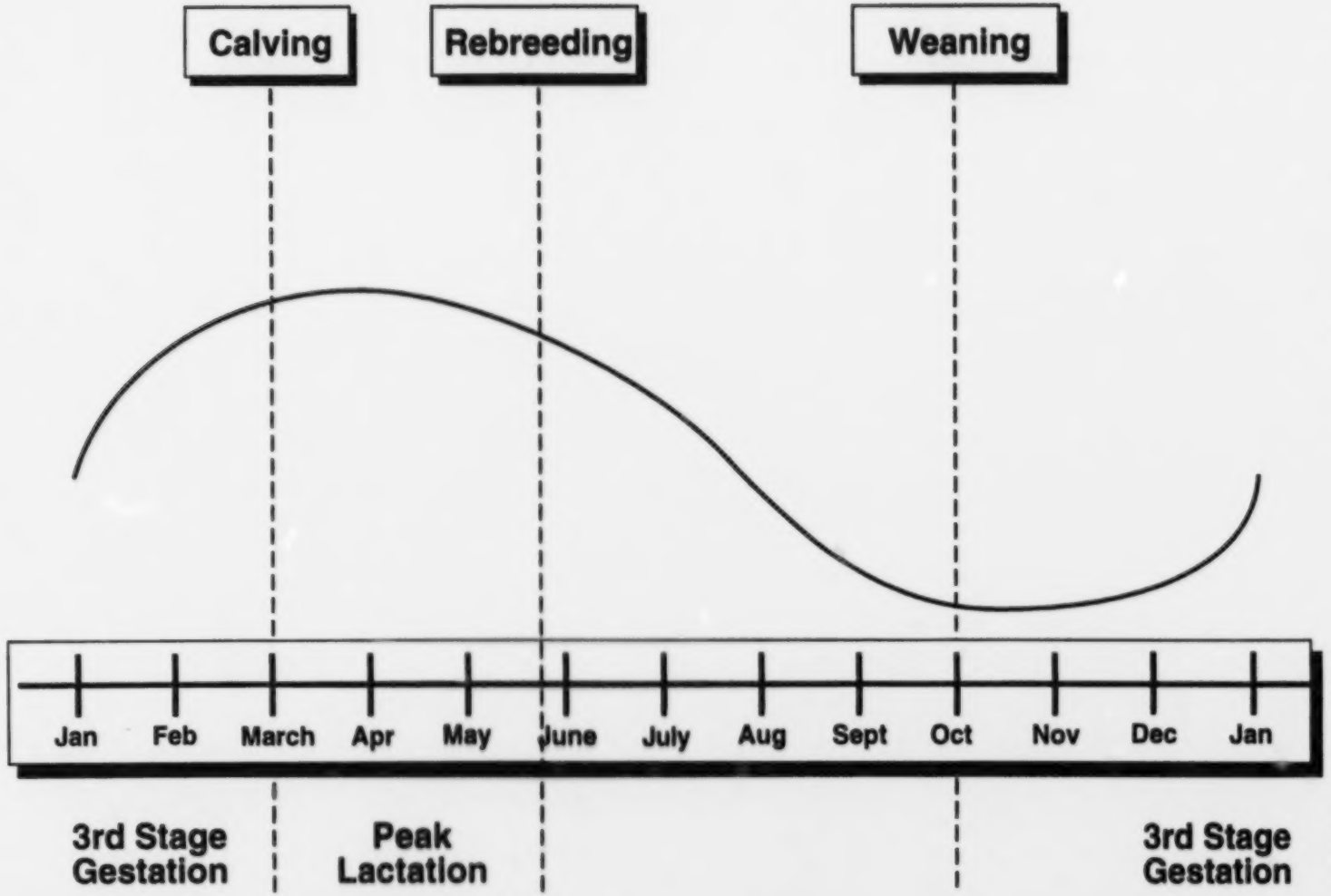
    a. Conception
    b. Growth and development
    c. Health
    d. Lactation

Complete the following short answer questions.

11. What are the nutrient needs of the sow during gestation? What are its nutrient needs during lactation?

12. Why are nutrients important for animal health?

Nutrient Requirements for a Cow through Life Stages



TM 3.1

Lesson 3: The Importance of Meeting Nutritional Needs

Nutrient Recommendations

Activity Length: 30 minutes

Procedure:

1. Hand out AS 3.1 (Student). Have students read the problem and answer any questions. Make sure that the students recognize the symptoms of the nutrient deficiency.

2. Ask the students what they need to decide to help Brandon. Help them to recognize that the decision to be made is what is causing Brandon's cows to be open and very thin.

3. Use the student reference and provide a supervised study period to fill in the chart.

4. After the supervised study time has expired, ask the students what a nutrient is. Discuss the definition of a nutrient.

5. Have a student write one possible cause of the deficiency on the chalkboard with the related facts. Discuss that possibility. Repeat for each item until all the possible causes are explained.

6. Have students fill in the accept/reject column and decide on a solution and recommendation.

Lesson 3: The Importance of Meeting Nutritional Needs Name_____

Nutrient Recommendations

Objective: Identify and recommend a nutrient solution for Brandon's cows.

Read the case study below. Then fill in the table to help identify the problem. In the "Related Facts" column, list both the components of the nutrient and its functions. Write "accept" or "reject" in the third column to indicate the cause of the problem. Then answer the question.

Brandon's family has a cow-calf operation, and he has a few cows of his own as a SAE project. They have a total of one hundred cows, which were bred to calve in March. Recently they were pregnancy checked, and Brandon and his family learned that 40 percent of the cows were not bred. The cows are being fed fescue hay, and all the cows seem to be eating, but they are still extremely thin. Brandon calls the veterinarian, who reviews his health program and takes samples from the animals. The vet says that the cows are healthy. Brandon is concerned and talks to his FFA advisor, extension specialist, and feed dealer. They suggest that the problem could be related to a nutrient deficiency. Brandon needs advice about what to do.

Possible Causes	Related Facts	Accept/Reject Cause
Water deficiency		
Protein deficiency		

Possible Causes	Related Facts	Accept/Reject Cause
Carbohydrate deficiency		
Fat deficiency		
Vitamin deficiency		
Mineral deficiency		

Decision/Recommendation: What is Brandon's problem? How can the problem be solved?

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 4: Meeting Nutritional Needs of Animals

Competency/Objective: Identify how the nutritional needs of animals may be met.

Study Questions

1. **What are sources of information on nutritional requirements?**
2. **What steps are necessary to meet the nutritional needs of animals?**
3. **What are sources of nutrients?**

References

1. *Introduction to Animal Nutrition (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1996.
2. Activity Sheets
   a) AS 4.1: Identifying Nutritional Requirements

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 4: Meeting Nutritional Needs of Animals

TEACHING PROCEDURES

A. Review

Lesson 3 discussed the six basic nutrients and the importance of recognizing the different nutritional needs of animals. This lesson will explain how an animal's nutritional needs may be met through research into the nutrients supplied by feeds and the nutritional requirements of animals.

B. Motivation

Ask students to quickly list the foods they eat for meals and snacks during a typical day. Have them try to identify the types of nutrients found in each food. Then inform students of the nutritional requirements for humans: six to eleven servings of bread, cereal, rice, and pasta; three to five servings of vegetables; two to four servings of fruit; two to three servings of meat, poultry, fish, dry beans, eggs, and nuts; two to three servings of milk, yogurt, and cheese; and sparing use of fats, oils, and sweets. Allow them to compare these requirements to their lists. Make a comparison between the human nutritional requirements and the students' diets and the management by producers of an animal's diet to meet its nutritional needs.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask students where information can be obtained about nutritional requirements. Discuss the information each source provides.

   What are sources of information on nutritional requirements?

   a) University Extension agricultural publications and livestock and dairy specialists
   b) Textbooks on animal nutrition
   c) Feed companies and dealers
   d) National Research Council

2. Discuss the steps that should be taken to meet the nutritional needs of an animal. Ask the students to explain the importance of each of the steps. Have students complete AS 4.1.

   What steps are necessary to meet the nutritional needs of animals?

   a) Find information sources on the nutritional needs of animals and the nutrient content of feeds.
   b) Next, identify the particular animal's nutritional needs.
      1) Identify the life stage of the animal.
      2) Determine the animal's weight and the size of its frame.
      3) Determine the desired performance (rate of gain).
      4) Look up all the nutritional requirements of the animal using this information.
   c) Identify the nutrients available in a feed.
      1) Identify the feeds that may be used.

2) Choose a version of a particular feed.
3) Look up the nutrients provided by that specific feed.

d) Match the feed to the animal's nutritional requirements to meet its needs. This is accomplished by balancing a ration.

3. List the nutrients and ask students what the sources of each of the six nutrients are. Discuss each source. Display some of the nutrient sources as visual aids.

What are sources of nutrients?

a) Water - Fresh water and feeds, which contain water
b) Protein - Amino acids in animal tissues, grains, and legumes
c) Carbohydrates - Sugars, starches, and fibers in grain and forages
d) Fats - Fatty acids in animal tissues, fats, and grains
e) Vitamins - Grass, sun-cured hay, and commercial feeds
f) Minerals - Plant and animal tissues and commercial feeds

F. Other Activities

Have students do research to determine the nutrients provided by different feeds.

G. Conclusion

Many sources of information about the nutrients in feed and the nutritional requirements of animals are available. Once sources are found, the animal's needs and then the feed nutrients should be identified. The two must be matched to meet the animal's needs. The necessary nutrients may be supplied to an animal through many different feed sources.

H. Answers to Activity Sheets

Answers are based on the University of Missouri Extension agricultural publications, using the Missouri recommended allowances.

1. a. 14.4%
   b. 85%
   c. 11.8 lbs.
2. a. 1 lb.
   b. 18%
   c. 0.7%
   d. 1.10%
3. a. 8.2%
   b. 0.28%
   c. 16.8 lbs.
4. a. 14%
   b. 0.6%
   c. 0.9%
   d. 0.65%
5. a. 7%
   b. 0.18%
   c. 18.1 lbs.
   d. 48.8%

I. Answers to Evaluation

1. a
2. c
3. d
4. d
5. a
6. d
7. c
8. d

9. Answers may include any three of the following: University Extension livestock and dairy specialists and agricultural publications, textbooks, feed dealers and companies, National Research Council.

10. a. Find information sources on the nutritional needs of animals and the nutrient content of feeds.
    b. Identify the animal's nutritional needs.
    c. Identify the nutrients available in the feed.
    d. Match the feed to the animal's nutritional requirements to meet its needs.

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UNIT - INTRODUCTION TO ANIMAL NUTRITION Name_____

Lesson 4: Meeting Nutritional Needs of Animals Date_____

EVALUATION

Circle the letter that corresponds to the best answer.

1. What is the first step to be taken in meeting an animal's nutritional needs?

   a. Find sources of information on the animal's needs and on feeds.
   b. Match the feed to the animal's nutritional requirements.
   c. Identify that animal's needs.
   d. Identify the feed nutrients provided.

2. In which step are the animal's weight and size considered?

   a. Find sources of information on the animal's needs and on feeds.
   b. Identify that animal's needs.
   c. Match the feed to the animal's nutritional requirements.
   d. Identify the feed nutrients provided.

3. Which of the following is <u>not</u> a part of identifying the animal's nutritional needs?

   a. Determining the desired performance
   b. Identifying the life stage of the animal
   c. Determining the animal's weight and frame size
   d. Identifying the animal's breed

4. Which nutrient may be provided by a pond?

   a. Carbohydrates
   b. Fats
   c. Proteins
   d. Water

5. Carbohydrates are found in _____.

   a. Grain
   b. Animal tissues
   c. Fats
   d. Fresh water

6. A good source of vitamins is _____.

   a. Animal tissue
   b. Fats
   c. Grain
   d. Sun-cured hay

7. Legumes are an important source of _____.

   a. Carbohydrates
   b. Fats
   c. Protein
   d. Vitamins

8. Minerals may be supplied to the animal through _____ and _____ tissues.

   a. Fat, legume
   b. Fat, animal
   c. Grain, plant
   d. Plant, animal

Complete the following short answer questions.

9. What are three sources of information on nutritional requirements?

   a.

   b.

   c.

10. What are the four general steps followed in meeting an animal's nutritional needs?

    a.

    b.

    c.

    d.

Lesson 4: Meeting Nutritional Needs of Animals Name_____

Identifying Nutritional Requirements

Objective: Identify the nutritional requirements of animals.

Using University of Missouri Extension Guides or other sources, answer the following questions to identify the nutritional requirements of animals.

1. A 500-pound medium-framed steer has an ADG of 3.0.
   a. What is the percent protein?_____
   b. What percent of TDN is needed?_____
   c. How much dry matter is needed?_____
2. What are the recommended allowances for a 25 to 45 pound growing swine?
   a. What is the expected daily gain?_____
   b. How much crude protein is needed?_____
   c. What is the total phosphorus needed?_____
   d. What percent lysine is needed in the diet?_____
3. An 800-pound pregnant yearling heifer in the last third of pregnancy has a ADG of 0.9.
   a. How much protein is required?_____
   b. What is the calcium requirement?_____
   c. How much dry matter should she intake?_____
4. What are the nutritional needs of a lactating sow?
   a. What is the crude protein requirement?_____
   b. How much valine is needed?_____
   c. What is the calcium requirement?_____
   d. What percent lysine is needed?_____

5. What are the nutritional requirements of a dry, pregnant, mature cow in the middle third of pregnancy weighing 1000 pounds?

   a. What is the percent protein required?_____

   b. How much calcium is required?_____

   c. What is the dry matter intake?_____

   d. What is the TDN?_____

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 5: Balancing a Ration

Competency/Objective: Demonstrate the procedure for balancing a ration for crude protein.

Study Questions

1. **Why is a balanced ration important for nutrition?**
2. **How is a ration balanced?**
3. **What factors influence the ingredients used to balance a ration?**

References

1. *Introduction to Animal Nutrition (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1996.
2. Transparency Masters
   a) TM 5.1: Pearson Square Method
3. Activity Sheets
   a) AS 5.1: Balancing Rations

UNIT - INTRODUCTION TO ANIMAL NUTRITION

Lesson 5: Balancing a Ration

TEACHING PROCEDURES

A. Review

Lesson 4 covered the steps that must be taken to determine an animal's nutritional requirements and the nutrient content of feeds. Lesson 5 will discuss how that information can be used to meet an animal's needs by balancing a ration. A ration is designed to meet the nutritional needs of the animal by supplying the proper amounts and proportions of feeds.

B. Motivation

1. Ask students what they think would happen if they ate only bread for every meal. What effect would it have on their health? How could they correct this problem? Compare this example to meeting the nutritional needs of a cattle herd. Ask students what would happen if cattle were fed only carbohydrates. Then ask how using a balanced feed ration could improve the herd.

2. The following example from Dr. Dan Netermeyer can be used to illustrate the importance of putting together a ration that not only has the necessary nutrients but also includes quality ingredients. The ration has 10 percent protein, 6.5 percent fat, 2.4 percent fiber, and 68 percent moisture, but it consists of 4 pairs of worn-out work shoes, 1 gallon of waste oil, 1 pail of crushed coal, and 68 pounds of water (from "OK, Feed Prices Are High, but Watch How You Save," *Today's Farmer*, February 1996, p. 18).

C. Assignment

D. Supervised Study

E. Discussion

1. Ask students what a balanced ration is. Discuss the importance of balancing a ration.

Why is a balanced ration important for nutrition?

a) Meets the nutrient needs for health and each life stage
b) Prevents nutritional deficiencies
c) Promotes maximum growth and production

2. Ask students what the methods of balancing a ration are. Discuss the methods. Use TM 5.1 to illustrate how to use the Pearson Square method by doing an example balancing a ration for crude protein. If available, a computer method may also be used.

How is a ration balanced?

a) Computer programs
   1) They are able to check whether multiple nutrients in a ration are balanced at one time.
   2) The computer does all figuring.
   3) It requires complete information.
   4) The operator needs to have a knowledge of nutrition.

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b) Trial and error method
   1) A combination of feeds is selected.
   2) The nutrient content is calculated and compared to the animal's nutritional needs.
   3) The process is repeated if its needs are not met.
   4) This method meets all the nutritional needs of the animal.

c) Pearson square method
   1) This method balances for only one nutrient at a time; it is mostly used for protein.
   2) Draw a square.
   3) Write the percent of the nutrient required by the animal in the middle of the square.
   4) Write the percent nutrient of each of the two feed items on its own corner on the left side.
   5) Find the diagonal differences and place the results on the right corners. Always subtract the smaller number from the larger.
   6) Add the two values and place the total at the bottom.
   7) Find the percentage of the ingredients by dividing the diagonal difference of each feed ingredient by the total.
   8) Find the number of pounds of each feed ingredient used by multiplying the percentage by the total number of pounds in the ration.
   9) Check to ensure that other nutritional requirements are met.

3. Ask students what factors influence the choice of ingredients used to balance the ration. Discuss the factors. Have students complete AS 5.1 on balancing rations and least cost.

What factors influence the ingredients used to balance a ration?

a) Least cost - The goal is to get the desired performance at the least cost to the producer.
   1) Balance a ration to determine the amount of each feed ingredient used.
   2) Find the total cost for each ration by multiplying the amount of each ingredient by its cost and adding to find the total cost.
   3) Compare the costs of balanced rations using different ingredients.
   4) Choose the ration with the least cost.

b) Ingredient availability - Geographical areas have different available feeds, depending on what is grown there and the manufacturing byproducts that are available.

F. Other Activities

Visit a local COOP, feed mill, or Extension service and have an employee demonstrate balancing a ration using their computer program.

G. Conclusion

A ration needs to be balanced to provide the proper amounts and proportions of nutrients for an animal. It is important to balance a ration to meet the animal's nutritional needs for health and the requirements of each life stage, to prevent nutritional deficiencies, and to promote maximum growth and production. Many methods may be used to balance a ration, such as computer programs, trial and error, and the Pearson Square method. Least cost and ingredient availability are factors to consider when balancing a ration.

H. Answers to Activity Sheets

Answers are based on University of Missouri Extension agricultural publications, using the Missouri recommended allowances.

1. Corn - 87 lbs.
   Supplement - 13 lbs.
2. Soybean meal - .74 lbs.
3. Grain sorghum - 897 lbs.
   Supplement - 103 lbs.
4. Yellow dent corn - 836 lbs.
   Supplement - 164 lbs.
5. Answers will vary depending on the current prices for grain sorghum, yellow dent corn, and supplement.

I. Answers to Evaluation

1. c
2. a
3. b
4. b
5. c
6. Corn - 857 lbs.
   Supplement - 143 lbs.
7. Answers will vary depending on current prices for corn, wheat, and supplement.

UNIT - INTRODUCTION TO ANIMAL NUTRITION Name_____

Lesson 5: Balancing a Ration Date_____

EVALUATION

Circle the letter that corresponds to the best answer.

1. A ration is balanced to prevent _____ _____.

   a. Growth and development
   b. Health
   c. Nutritional deficiencies
   d. Production

2. A balanced ration needs to meet the animal's specific nutritional requirements for a life stage such as _____ .

   a. Lactation
   b. Deficiency
   c. Production
   d. Proportion

3. Which method balances for only one nutrient at a time?

   a. Computerized method
   b. Pearson Square method
   c. Trial and error method
   d. Two-Two method

4. What are the two factors that influence the types of ingredients used in a ration?

   a. Animal growth and least cost
   b. Least cost and ingredient availability
   c. Balancing method and ingredient availability
   d. Nutrient requirements and animal growth

5. In balancing a ration, ingredient availability for producers depends on _____.

   a. Animal needs
   b. Least cost
   c. Location
   d. Proportions

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Using the Pearson Square method, balance the following rations. Round to the nearest pound.

6. A sow needs a 14% crude protein ration. Corn and a supplement is fed, with 9% protein in corn and 44% in the supplement. Calculate how many pounds of corn and supplement are needed in a 1000 pound ration.

Corn _____
Supplement _____

Use the Pearson Square method to balance the rations. Calculate the cost of each ration. Show the work for balancing both rations and calculating the cost of each.

7. A feeder pig weighs 40 pounds and needs 18% protein. Corn with 9% protein is used in one ration and wheat with 11.4% is used in the other ration. Supplement with 40% protein is used in both rations. Use current prices for corn, wheat, and supplement to calculate total cost. (There are approximately 56 pounds of corn and 60 pounds of wheat in a bushel.)

Which ration has the lowest cost? _____

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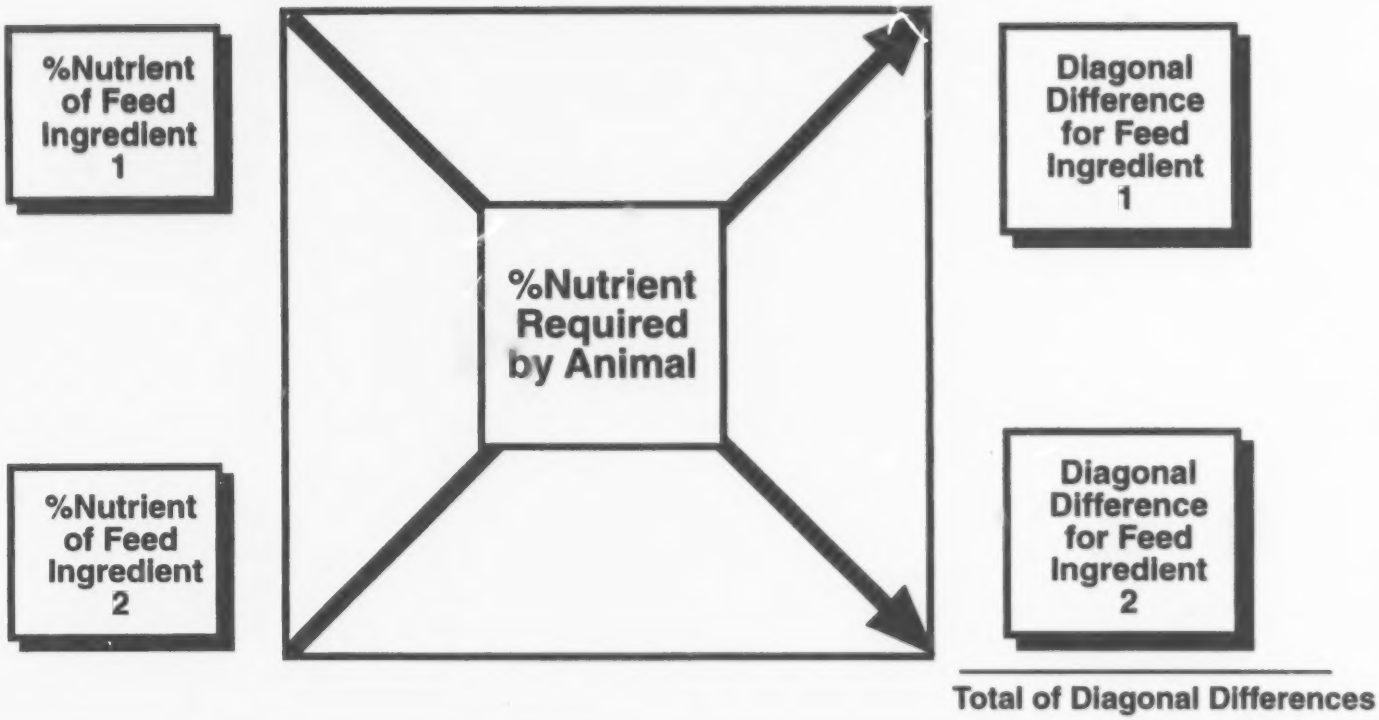
Pearson Square Method


%Nutrient of Feed Ingredient 1
%Nutrient Required by Animal
Diagonal Difference for Feed Ingredient 1
%Nutrient of Feed Ingredient 2
Diagonal Difference for Feed Ingredient 2
Total of Diagonal Differences

$$\frac{\text{Diagonal Difference - Feed 1}}{\text{Total}} \times \text{Total Pounds of Ration} = \text{Pounds Needed of Feed Ingredient 1}$$

$$\frac{\text{Diagonal Difference - Feed 2}}{\text{Total}} \times \text{Total Pounds of Ration} = \text{Pounds Needed of Feed Ingredient 2}$$

TM 5.1

Lesson 5: Balancing Rations Name_____

Balancing Rations

Objective: Balance rations for protein using the Pearson Square method.

Balance the following rations using the Pearson Square method. Round to the nearest pound or dollar. Use sources to obtain any additional information needed to balance the rations.

1. A bred gilt requires a 13% protein ration. Corn with 9% protein and supplement with 40% protein is used in the ration. Find the number of pounds of corn and supplement needed to make a 100 lb. ration.

Corn _____
Supplement _____

2. A 1400-pound cow in the second trimester of pregnancy needs 6.9% protein. She is given 23.3 lbs. of feed, most of which is mature smooth brome hay at 5.5% protein. How many pounds of soybean meal should the cow be given to make sure that she receives 6.9% protein? The soybean meal has 49.6% protein.

Soybean meal _____

3. A lactating sow with a litter is fed high protein grain sorghum and a supplement with 40% protein. Find the number of pounds of high protein grain sorghum and supplement in a 1000 lb. ration.

Grain sorghum _____
Supplement _____

4. A lactating sow with a litter is fed yellow dent corn and a supplement with 40% protein. Find the number of pounds of corn and supplement in a 1000 pound ration.

Corn _____
Supplement _____

5. Using current prices, calculate the prices of the rations in Problems 3 and 4. Determine which ration has the least cost and should be fed to the lactating sow.

Cost of Problem 3 _____
Cost of Problem 4 _____
Which should be fed? _____

APPENDIX A

Table 2 Requirements of Breeding Cattle (Nutrient Concentration in Dry Matter)

Wt[a] lbs.	ADG lbs.	DM[b] lbs.	Prot[c] %	NE_m[d] Mcal/lb	NE_g Mcal/lb	TDN %	Ca %	P %
Pregnant Yearling Heifers - Last Third of Pregnancy								
700	0.9	15.3	8.4	0.52	NA	55.4	0.27	0.20
700	1.4	15.8	9.0	0.60	0.34	60.3	0.33	0.21
700	1.9	15.8	9.8	0.70	0.43	67.0	0.33	0.21
750	0.9	16.1	8.3	0.52	NA	55.1	0.27	0.19
750	1.4	16.6	8.9	0.60	0.33	59.9	0.32	0.21
750	1.9	16.6	9.5	0.69	0.42	66.5	0.37	0.23
800	0.9	16.8	8.2	0.51	NA	54.8	0.28	0.20
800	1.4	17.4	8.8	0.59	0.33	59.6	0.33	0.21
800	1.9	17.5	9.3	0.69	0.42	66.1	0.35	0.21
850	0.9	17.6	8.2	0.51	NA	54.5	0.26	0.20
850	1.4	18.2	8.6	0.59	0.32	59.3	0.30	0.21
850	1.9	18.3	9.1	0.68	0.41	65.7	0.34	0.22
900	0.9	18.3	8.1	0.51	NA	54.3	0.26	0.20
900	1.4	19.0	8.5	0.58	0.32	59.1	0.30	0.21
900	1.9	19.2	9.0	0.68	0.41	65.4	0.32	0.21
950	0.9	19.0	8.0	0.50	NA	54.1	0.27	0.20
950	1.4	19.8	8.4	0.58	0.32	58.9	0.29	0.21
950	1.9	20.0	8.8	0.67	0.40	65.1	0.32	0.21
Dry pregnant mature cows - Middle third of pregnancy								
800	0.0	15.3	7.1	0.42	NA	48.8	0.17	0.17
900	0.0	16.7	7.0	0.42	NA	48.8	0.18	0.18
1000	0.0	18.1	7.0	0.42	NA	48.8	0.18	0.18
1100	0.0	19.5	7.0	0.42	NA	48.8	0.19	0.19
1200	0.0	20.8	6.9	0.42	NA	48.8	0.19	0.19
1300	0.0	22.0	6.9	0.42	NA	48.8	0.20	0.20
1400	0.0	23.3	6.9	0.42	NA	48.8	0.20	0.20
Dry pregnant mature cows - Last third of pregnancy								
800	0.9	16.8	8.2	0.51	NA	54.5	0.26	0.20
900	0.9	18.2	8.0	0.50	NA	54.0	0.27	0.21
1000	0.9	19.6	7.9	0.50	NA	53.6	0.26	0.20
1100	0.9	21.0	7.8	0.49	NA	53.2	0.26	0.21
1200	0.9	22.3	7.8	0.49	NA	52.9	0.26	0.21
1300	0.9	23.6	7.7	0.48	NA	52.7	0.26	0.21
1400	0.9	24.9	7.6	0.48	NA	52.5	0.26	0.21
Two-year-old heifers nursing calves - First 3-4 months postpartum - 10 lb milk/day								
700	0.5	15.9	11.3	0.67	0.40	65.1	0.36	0.24
750	0.5	16.7	11.0	0.66	0.40	64.4	0.34	0.24
800	0.5	17.6	10.8	0.66	0.39	63.8	0.34	0.24
850	0.5	18.4	10.6	0.65	0.38	63.2	0.33	0.23
900	0.5	19.2	10.4	0.64	0.37	62.7	0.32	0.23
950	0.5	20.0	10.2	0.63	0.37	62.3	0.31	0.23
1000	0.5	20.8	10.0	0.62	0.36	61.9	0.31	0.23

From *Nutrient Requirements for Growing and Finishing Beef Cattle (G2067)*, University Extension, University of Missouri-Columbia

APPENDIX B

TABLE 2 Requirements for Growing and Finishing Beef Cattle (Nutrient Concentration in Diet Dry Matter).

Wt[a] lbs.	ADG lbs.	DM[b] lbs.	Prot %	NE_m Mcal/lb	NE_g Mcal/lb	TDN %	Ca %	P %
Medium-frame steer calves								
300	0.5	7.8	9.6	0.50	0.25	54.0	0.31	0.20
	1.0	8.4	11.4	0.57	0.31	58.5	0.45	0.24
	1.5	8.7	13.2	0.64	0.38	63.0	0.58	0.28
	2.0	8.9	14.8	0.70	0.44	67.5	0.72	0.32
	2.5	8.9	16.7	0.79	0.51	73.5	0.87	0.37
	3.0	8.0	19.9	0.95	0.64	85.0	1.13	0.47
400	0.5	9.7	8.9	0.50	0.25	54.0	0.27	0.18
	1.0	10.4	10.3	0.57	0.31	58.5	0.38	0.21
	1.5	10.8	11.5	0.64	0.38	63.0	0.47	0.25
	2.0	11.0	12.7	0.70	0.44	67.5	0.56	0.26
	2.5	11.0	14.2	0.79	0.51	73.5	0.68	0.30
	3.0	10.0	16.6	0.95	0.64	85.0	0.86	0.37
500	0.5	11.5	8.5	0.50	0.25	54.0	0.25	0.17
	1.0	12.3	9.5	0.57	0.31	58.5	0.32	0.20
	1.5	12.8	10.5	0.64	0.38	63.0	0.40	0.22
	2.0	13.1	11.4	0.70	0.44	67.5	0.47	0.24
	2.5	13.0	12.5	0.79	0.51	73.5	0.56	0.27
	3.0	11.8	14.4	0.95	0.64	85.0	0.69	0.32
600	0.5	13.2	8.2	0.50	0.25	54.0	0.23	0.18
	1.0	14.1	9.0	0.57	0.31	58.5	0.28	0.19
	1.5	14.7	9.8	0.64	0.38	63.0	0.35	0.21
	2.0	15.0	10.5	0.70	0.44	67.5	0.40	0.22
	2.5	14.9	11.4	0.79	0.51	73.5	0.46	0.24
	3.0	13.5	12.9	0.95	0.64	85.0	0.57	0.29
700	0.5	14.8	7.9	0.50	0.25	54.0	0.22	0.18
	1.0	15.8	8.6	0.57	0.31	58.5	0.27	0.18
	1.5	16.5	9.2	0.64	0.38	63.0	0.31	0.20
	2.0	16.8	9.8	0.70	0.44	67.5	0.34	0.21
	2.5	16.7	10.5	0.79	0.51	73.5	0.40	0.22
	3.0	15.2	11.7	0.95	0.64	85.0	0.49	0.26
800	0.5	16.4	7.7	0.50	0.25	54.0	0.22	0.17
	1.0	17.5	8.3	0.57	0.31	58.5	0.24	0.19
	1.5	18.2	8.8	0.64	0.38	63.0	0.28	0.19
	2.0	18.6	9.2	0.70	0.44	67.5	0.31	0.20
	2.5	18.5	9.8	0.79	0.51	73.5	0.35	0.21
	3.0	16.8	10.8	0.95	0.64	85.0	0.42	0.25

From *Nutrient Requirements for Beef Breeding Animals (G2068)*, University Extension, University of Missouri-Columbia

APPENDIX C

Table 1. Nutrient Requirements and Allowances for Growing Swine

National Research Council					Missouri Recommended Allowances			
10-25	25-45	45-110	110-230	*Live Weight (lbs)*	10-25	25-45	45-110	110-230
.55	1.0	1.54	1.80	*Expected Daily Gain (lbs)*	.55	1.0	1.54	1.80
Percent in diet					Percent in diet			
20	18	15	13	Crude Protein	20	18	16	14
.80	.70	.60	.50	Calcium	.90	.80	.75	.65
.65	.60	.50	.40	Phosphorus (Total)	.80	.70	.65	.55
.50	.40	.25	.10	Arginine	.50	.40	.25	.10
.31	.25	.22	.18	Histidine	.31	.25	.22	.18
.65	.53	.46	.38	Isoleucine	.65	.53	.46	.38
.85	.70	.60	.50	Leucine	.85	.70	.60	.50
1.15	.95	.75	.60	Lysine	1.25	1.10	.80	.65
.58	.48	.41	.34	Methionine + cystine	.60	.50	.41	.35
.94	.77	.66	.55	Phenylalanine + tyrosine	.94	.77	.66	.55
.68	.56	.48	.40	Threonine	.70	.60	.50	.45
.17	.14	.12	.10	Tryptophan	.20	.18	.15	.13
.68	.56	.48	.40	Valine	.68	.56	.48	.40

Missouri Recommended Nutrient Addition Per Ton

Nutrient	Unit	Additions per ton: Grower Rations	Finisher Rations
Sodium	lb	5	5
Chlorine		-	-
Iron	g	100	60
Zinc	g	100	60
Manganese	g	16	8
Copper	g	10	6
Iodine	g	.27	.18
Selenium*	g	.27	.27
Vitamin A	Mil.I.U.	5	3
Vitamin D	Thou.I.U.	500	300
Vitamin E	Thou.I.U.	20.0	10
Vitamin K	g	2.0	1.0
Riboflavin	g	4.0	2.0
Niacin	g	30	8
Pantothenic acid	g	16	8
Choline	g	200	100
Vitamin B$_{12}$	mg	25	12.5

*Maximum legal limit (.3 ppm)

From *Nutrient Requirements of Swine and Recommendations for Missouri (G2320)*, University Extension, University of Missouri-Columbia

Table 2. Nutrient Requirements of Breeding Swine: Percentage or Amount Per Pound of Diet

National Research Council			Missouri Recommended Allowances	
Bred Gilts & Sows Young & Adult Boars	Lactating Gilts & Sows	Nutrients	Bred Gilts & Sows Young & Adult Boars	Lactating Gilts & Sows
Percent in diet			Percent in diet	
12	13	Crude Protein	13	14
.75	.75	Calcium	.90	.90
.60	.60	Phosphorus	.80	.80
—	.4	Arginine	—	.4
.15	.25	Histidine	.15	.25
.30	.39	Isoleucine	.30	.39
.30	.48	Leucine	.30	.48
.43	.60	Lysine	.5	.65
.23	.36	Methionine + cystine	.23	.36
.45	.70	Phenylalanine + tyrosine	.45	.70
.30	.43	Threonine	.35	.45
.09	.12	Tryptophan	.11	.13
.32	.60	Valine	.32	.60

Missouri Recommended Nutrient Additions Per Ton

Nutrient	Unit	Breeding Stock Rations
Salt	lb	10
Iron	g	100
Zinc	g	100
Manganese	g	16
Copper	g	10
Iodine	g	.27
Selenium	g	.27
Vitamin A	Mil.I.U.	5.0
Vitamin D	Thou.I.U.	500
Vitamin E	Thou.I.U.	25
Vitamin K	g	2.0
Riboflavin	g	5.0
Niacin	g	30.0
Pantothenic acid	g	18.0
Vitamin B_{12}	mg	25.0
Biotin	mg	200
Folacin	mg	300

APPENDIX D

Table 1. Composition of Feeds Commonly Used in Beef Cattle Ration (As Fed Basis)

Use with NRC Table 1 in UMC Guides 2067 and 2068

	Dry Matter %	Crude Protein %	NEm Mcal/lb	NEg Mcal/lb	TDN %	Fat %	Crude Fiber %	Calcium %	Phos-phorus %	Potas-ium %	Sodium %	Sulfur %	Zinc PPM
Concentrates													
Barley	88.0	11.9	0.83	0.56	74	1.8	5.0	0.04	0.33	0.41	0.03	0.15	17
Brewers Grains, Dried	92.0	27.1	0.63	0.38	61	6.6	13.2	0.30	0.51	0.08	0.21	0.29	28
Corn													
Yellow Dent #2	88.0	8.9	0.90	0.62	79	3.7	1.9	0.02	0.31	0.33	0.02	0.12	14
Corn & Cob Meal	87.0	7.8	0.80	0.54	72	3.2	8.2	0.06	0.23	0.46	0.02	0.14	12
Corn Gluten Feed	90.0	23.0	0.83	0.56	75	2.2	8.7	0.32	0.74	0.58	0.95	0.21	65
Distillers Grain Corn	94.0	22.0	0.90	0.49	81	9.2	11.4	0.10	0.40	0.17	0.09	0.43	33
Hominy Feed	90.0	10.4	0.99	0.68	85	6.9	6.0	0.05	0.51	0.59	0.08	0.03	3
Molasses													
Beet	78.0	6.6	0.68	0.45	62	0.2	0.0	0.13	0.02	4.73	1.15	0.47	14
Cane	75.0	4.4	0.58	0.37	54	0.1	0.0	0.75	0.08	2.88	0.17	0.35	23
Cane, Dried	94.0	9.7	0.70	0.44	66	0.8	6.3	1.03	0.14	3.38	0.19	0.43	31
Oats													
Grain	89.0	11.8	0.75	0.49	69	4.8	10.8	0.06	0.34	0.39	0.07	0.20	37
Mill By Product	89.0	7.1	0.34	0.00	29	2.3	22.3	0.11	0.21	0.53	-.-	0.21	-.-
Groats	90.0	15.9	0.95	0.65	85	6.2	2.5	0.07	0.43	0.35	0.05	0.20	0
Sorghum													
Grain (8-10% Protein)	87.0	8.8	0.81	0.55	73	3.0	2.3	0.03	0.31	0.33	0.01	0.11	16
Grain (10%+ Protein)	88.0	11.0	0.81	0.55	73	2.1	2.3	0.04	0.32	0.33	0.01	0.11	16
Rice													
Bran	91.0	12.7	0.67	0.43	64	14.4	11.8	0.07	1.53	1.73	0.04	0.18	30
Mill By-Product	91.0	6.4	0.39	0.00	38	5.2	29.1	0.36	0.56	-.-	-.-	-.-	-.-
Soybean Hulls	91.0	11.0	0.67	0.42	65	1.9	36.5	0.54	0.19	1.16	0.01	0.08	-.-
Wheat													
Bran	89.0	15.2	0.66	0.42	62	3.9	10.1	0.12	1.23	1.39	0.04	0.22	94
Hard Winter	88.0	12.7	0.87	0.60	77	1.6	2.5	0.04	0.38	0.43	0.02	0.13	38
Soft Winter	88.0	11.4	0.88	0.61	78	1.6	2.1	0.04	0.38	0.40	0.01	0.11	42
Mids	89.0	16.4	0.65	0.45	61	4.4	7.3	0.12	0.88	1.01	0.17	0.18	103
Shorts	88.0	16.4	0.69	0.40	64	4.6	6.8	0.09	0.80	0.93	0.03	0.19	109

From *Feed Composition Tables (G2051)*, University Extension, University of Missouri-Columbia

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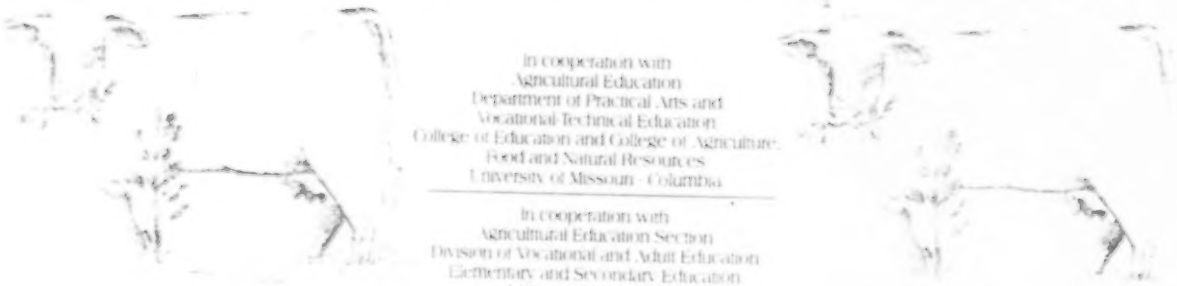
Introduction
To

Animal Nutrition

Student
Reference



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FOREWORD

The development of the *Introduction to Animal Nutrition* curriculum guide is the result of suggestions by the MVATA Teaching Aids Committee. The Animal Nutrition Advisory Committee suggested the topics to be included and reviewed the materials.

This student reference contains five lessons. Topics include the monogastric and ruminant digestive systems, the importance of meeting the nutritional needs of animals and how to meet them, and balancing a ration. An instructor's guide can be purchased separately.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

The instructor's guide to accompany this student reference incorporates the needed component parts to aid agriculture teachers in the implementation of VIMS.

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INTRODUCTION TO ANIMAL NUTRITION

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X 00

Feeding animals correctly, in terms of both the amount and type of feed supplied, is extremely important for production, since it helps to ensure that the animal is healthy and productive. It is therefore important to understand exactly how the digestive system processes feed so the animal can use nutrients properly. This lesson covers one type of digestive system, the monogastric system.

Monogastric Animals

The term "monogastric" refers to the structure of the stomach. In a monogastric digestive system, the stomach has a simple structure consisting of a single compartment. A number of species have a monogastric digestive system, including swine, horses, dogs, rabbits, and fowl. All of the mammals listed here have similar systems, although some minor differences do exist between them. Fowl, however, have a digestive system that differs from the others, including organs not found in the other species.

Parts of the Monogastric Digestive System

As feed moves through the monogastric digestive system (also termed the alimentary canal) of mammals, it passes through a number of different parts (Figure 1.1). Digestion begins when feed enters the mouth. The feed is then carried through a tube called the esophagus to the stomach. When leaving the stomach, the feed moves into the first section of the small intestine, which is called the duodenum. After traveling through the rest of the small intestine, what remains of the feed is first emptied into the part of the large intestine named the cecum and then into the colon. Finally, the waste products are passed into the lower end of the large intestine, which is referred to as the rectum, and out of the body through the anus.

While they are not a part of the digestive system, the pancreas, gall bladder, and liver also play a role in digestion. They release substances that aid the digestive system in performing its function. However the horse, unlike the other animals, does not have a pancreas.

The path followed by feed in fowl differs somewhat due to the different parts of its digestive system (Figure 1.2). Feed enters the system through the beak and passes through the esophagus, which is called the gullet, to an organ referred to as the crop. From the crop it passes into the glandular stomach, or proventriculus, and then the gizzard,

Figure 1.1 - Swine Digestive System

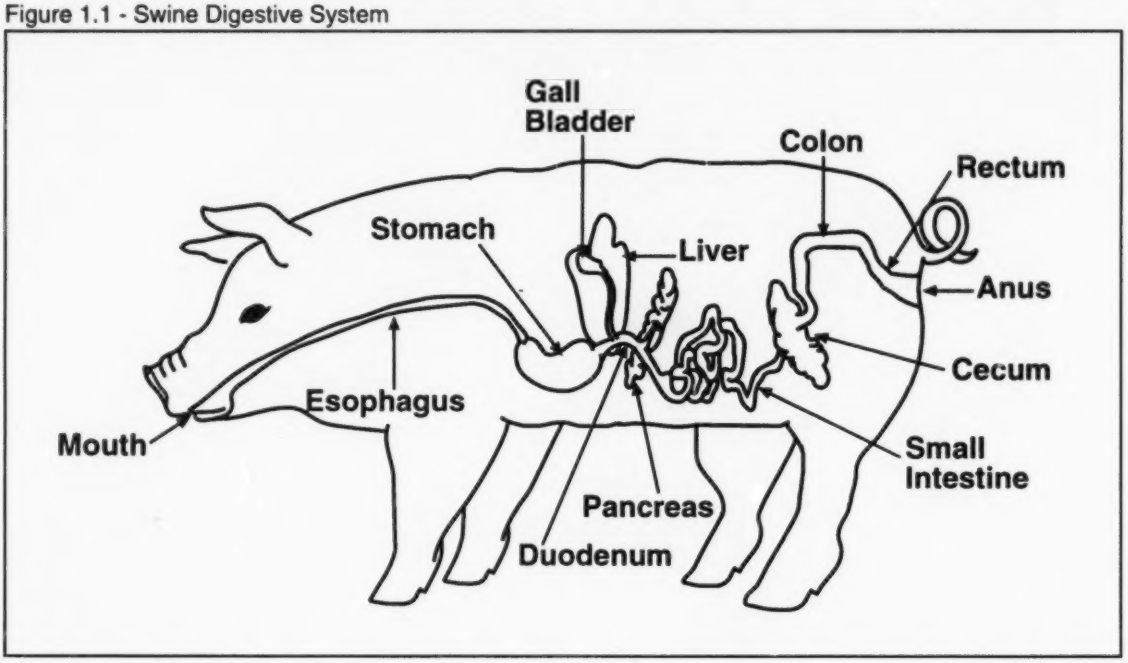
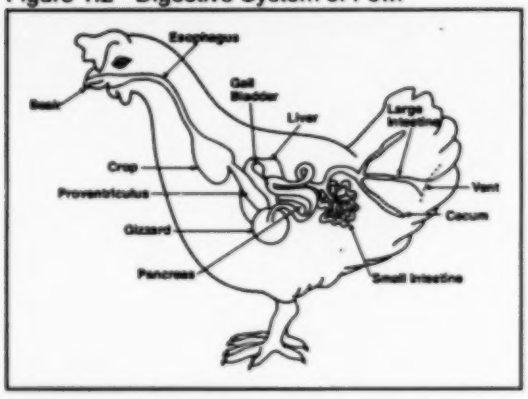


Figure 1.2 - Digestive System of Fowl



or ventriculus, before entering the small intestine. At the point where the small intestine and large intestine join are two ceca. After passing the ceca, the undigested material moves through the large intestine to the cloaca and exits the body through the vent.

Functions of the Parts

The parts of the mammalian monogastric digestive system can be divided into four sections based on their functions. The sections consist of the parts leading to the small intestine, the small intestine, the large intestine, and the parts allowing the exit of solid wastes, or feces.

The parts leading to the small intestine reduce the size of feed particles. The process begins in the mouth as the teeth are used to grind feed into smaller pieces that are moved to the throat by the tongue. The tube-like esophagus carries these pieces to the stomach, a muscular organ that stores food before it passes into the small intestine. Digestion begins in the stomach.

The primary function of the small intestine is to further digest and then absorb the nutrients found in food. The digestive processes started in the stomach are continued in the duodenum. Nutrients are absorbed into the bloodstream through the intestinal walls in the remainder of the small intestine.

The next section of the digestive system, which consists of most of the large intestine, is designed to absorb water and mold indigestible feed wastes into a solid form. The cecum, also referred to as the blind gut, contains microorganisms. Its function varies depending on the species. In some species it has little or no effect on digestion. In the horse and rabbit, however, the cecum is enlarged, which allows the microorganisms to ferment roughage, which is feed (like hay, grass, and grass products) that has a lot of fiber and few digestible nutrients. The fermentation breaks down the roughage for absorption into the blood. These two species are therefore able to make efficient use of plant materials in their diets. After passing through the cecum, the feed enters the colon, which absorbs water and forms the feces. Some nutrients are absorbed in the colon as well.

The parts allowing the exit of the feces are the rectum and the anus. The rectum carries the feces to the anus. The anus passes the solid wastes out of the body.

The digestive system of fowl functions somewhat differently. Fowl have no teeth with which to chew and instead use the beak to break feed down for swallowing. After passing through the gullet, feed is stored in the crop and softened for digestion before it enters the stomach. Digestion begins in the glandular stomach. The feed then passes into the gizzard where it is ground by muscular contractions before entering the small intestine for digestion and absorption. The two ceca contain bacteria but have little role in digestion; fowl therefore cannot digest fibrous feeds like hay. The large intestine carries wastes to the cloaca, the junction of the reproductive and digestive systems. The vent allows wastes to exit the body.

Digestive Juices and Enzymes

Digestion is the breakdown of food into soluble particles that can then be passed through the intestinal wall and absorbed into the blood system for use by the animal. Digestive juices and enzymes play a major role in digestion.

Digestive juices are fluids that are secreted into the digestive system from glands or tissues. Substances called enzymes are found in these fluids. An enzyme speeds up chemical reactions, allowing feed to be digested and absorbed. Table 1.1 shows digestive juices and enzymes found in the monogastric digestive system.

Table 1.1 - Digestive Juices and Enzymes

Type of Digestive Juices	Enzyme
Saliva	Amylase
Gastric	Pepsin Rennin Lipase
Pancreatic	Lipase Trypsin Chymotrypsin Amylase
Bile	No enzyme present
Intestinal	Peptidase Maltase Sucrase Lactase

In mammals, digestive juices begin to break down feed as soon as it enters the mouth. Saliva from the salivary glands in the mouth lubricates the feed for passage into the digestive system. It also contains the enzyme amylase. As saliva mixes with the food, amylase begins the breakdown of starches into sugars that can be absorbed by the body. It continues to act until neutralized in the stomach.

Once the food moves into the stomach, other digestive juices begin to work on the feed. One of the chief components of the gastric juices secreted by the stomach wall is diluted hydrochloric acid (HCl), a corrosive substance that stops the action of amylase. Another component of the juices is gastrin, which stimulates the stomach to produce more gastric juices. The gastric juices also include the enzymes pepsin, rennin, and gastric lipase. Pepsin begins the digestion of proteins, rennin curdles a protein in milk, and lipase begins the breakdown of fats. Mucus is also present in the stomach to protect the stomach lining from the acidic environment that is created by the gastric juices.

Other digestive juices are released into the small intestine. For example, bile, which is secreted by the liver and stored in the gall bladder, is released into the duodenum along with digestive juices from the pancreas. Bile helps to liquefy fats for absorption. The pancreatic juices contain several enzymes, including pancreatic lipase, which is aided by bile in the further breakdown of fats; trypsin, which breaks down proteins; chymotrypsin, which also acts on proteins; and amylase, which continues to work on starch. In addition, intestinal juices containing the enzymes peptidase, maltase, sucrase, and lactase are produced in the small intestine itself. Peptidase breaks down proteins, while maltase, sucrase, and lactase work on sugars and starches.

In fowl, digestive juices also convert the nutrients in feed into a useable form. Little saliva is present in the mouth, but saliva and secretions from the wall of the crop soften the feed for digestion. In the proventriculus, gastric juices containing HCL and pepsin are secreted, and the pepsin begins the digestion of proteins. The digestive juices are further mixed with the feed as it is ground in the gizzard. In the small intestine, bile and pancreatic juices with amylase, trypsin, and lipase are released; they function in the same way as they do in mammals. The intestinal juices, which contain peptidase, maltase, sucrase, and lactase, also have the same functions as in the mammalian system.

Summary

The stomach of a monogastric animal has a simple structure consisting of a single compartment. The various parts of its digestive system work together to digest food and absorb its nutrients into the body in a useable form. Digestive juices and enzymes play an important role in breaking down feed for absorption. Swine, horses, dogs, and rabbits have this type of digestive system. Fowl also have a monogastric digestive system, although the digestive tract found in fowl has several differences from that found in mammals.

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In contrast to an animal with a monogastric digestive system, a ruminant has four stomach compartments and can utilize some feeds more efficiently than a monogastric animal. Ruminants are important to the animal industry because they can use hay and pasture productively.

Parts of the Ruminant Digestive System

Two common livestock species have a ruminant digestive system. Cattle, both dairy and beef, and sheep are ruminants. The parts and their functions are similar in both species.

Some of the parts of the ruminant digestive system are the same as those of the monogastric digestive system, but other parts are very different. As in the monogastric digestive system, food enters into the system through the mouth and then passes through the esophagus to the stomach. In the ruminant, the stomach is divided into four compartments, called the rumen, reticulum, omasum, and abomasum. Depending on the type of feed, it may pass through all or some of these compartments as it moves through the stomach. When the stomach completes its functions, the feed moves to the small intestine and proceeds through the cecum, colon, and rectum of the large intestine to the anus. The digestive system of cattle is illustrated in Figure 2.1.

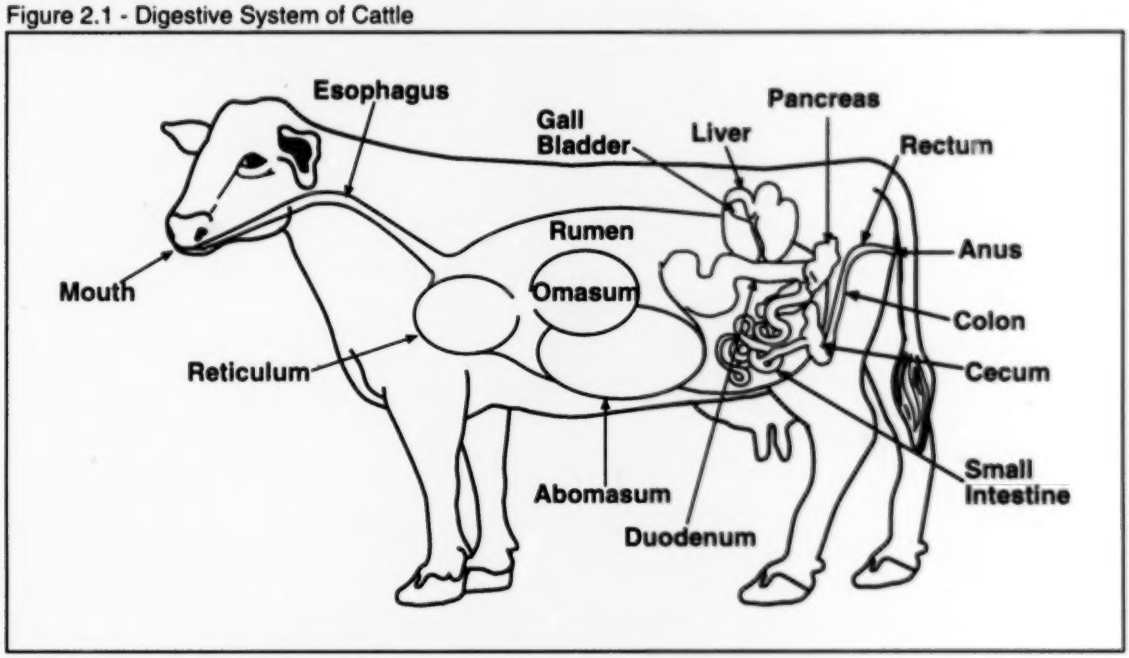
Functions of the Parts

Each of the parts of the ruminant digestive system aids in the process of extracting the nutrients needed by the animal from feed. Although the parts of the system have some similarities in function to those of the monogastric digestive system, the process of digestion is much more complex due to structure of the stomach.

Mouth - The mouth carries feed into the digestive system. In cattle, the tongue grabs the grass or other feed and brings it into the mouth. The tongue also moves feed to the throat. The cow has front teeth only in the lower jaw, with a dental pad in the upper jaw; when grass is pulled into the mouth, the teeth cut the grass against the dental pad. The mouth also has upper and lower back teeth for chewing cud and other types of feed. Sheep use their lips to bring food into the mouth when grazing.

Esophagus - Feed is transported back and forth from the mouth to the stomach through the esophagus.

Figure 2.1 - Digestive System of Cattle



Stomach - Like the monogastric stomach, the main function of the stomach of the ruminant is to break down feed. Each of the four stomach compartments has its own unique function. Figure 2.2 illustrates the four compartments of the stomach.

Rumen - The rumen, which is also the called the paunch, is the largest of the stomach compartments. It helps to break feed down so that it may be digested.

Reticulum - The reticulum is also called the honeycomb because of the texture of the inner wall of the compartment. It pumps roughage back to the mouth through the esophagus for rumination, which is the racing of feed in the form of the cud. The reticulum also works with the rumen in the breakdown of feed.

Omasum - The function of the omasum, or manyplies, is not fully understood. However, scientists have found that the omasum absorbs some water and is involved in the absorption of nutrients.

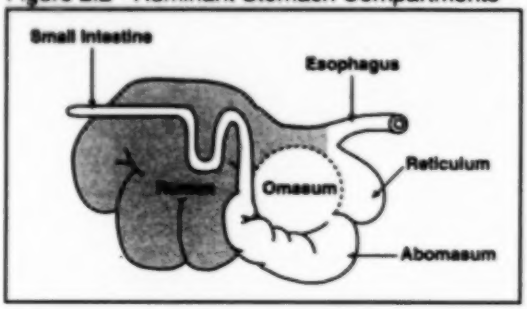
Abomasum - The abomasum is referred to as the true stomach. Its functions are very similar to those of the monogastric stomach. In the abomasum, digestive juices containing acids and enzymes are added to aid in digestion.

Small intestine - In the first portion of the small intestine, called the duodenum, the digestive process started in the stomach continues. Nutrients are absorbed into the bloodstream through the walls of the remainder of the small intestine. Once the nutrients enter the bloodstream, they travel throughout the body to fuel life processes.

Large intestine - The large intestine consists of three parts, the cecum, colon, and rectum. Within the large intestine of the ruminant, the cecum plays a minor role in the further breakdown of roughage. The colon absorbs water and forms undigested wastes into feces; some absorption of nutrients also takes place. The feces are stored in the rectum before being passed out of the body.

Anus - The anus is the opening through which undigestible solid wastes exit from the body. Any portion of the feed not absorbed into the bloodstream is excreted through the anus.

Figure 2.2 - Ruminant Stomach Compartments



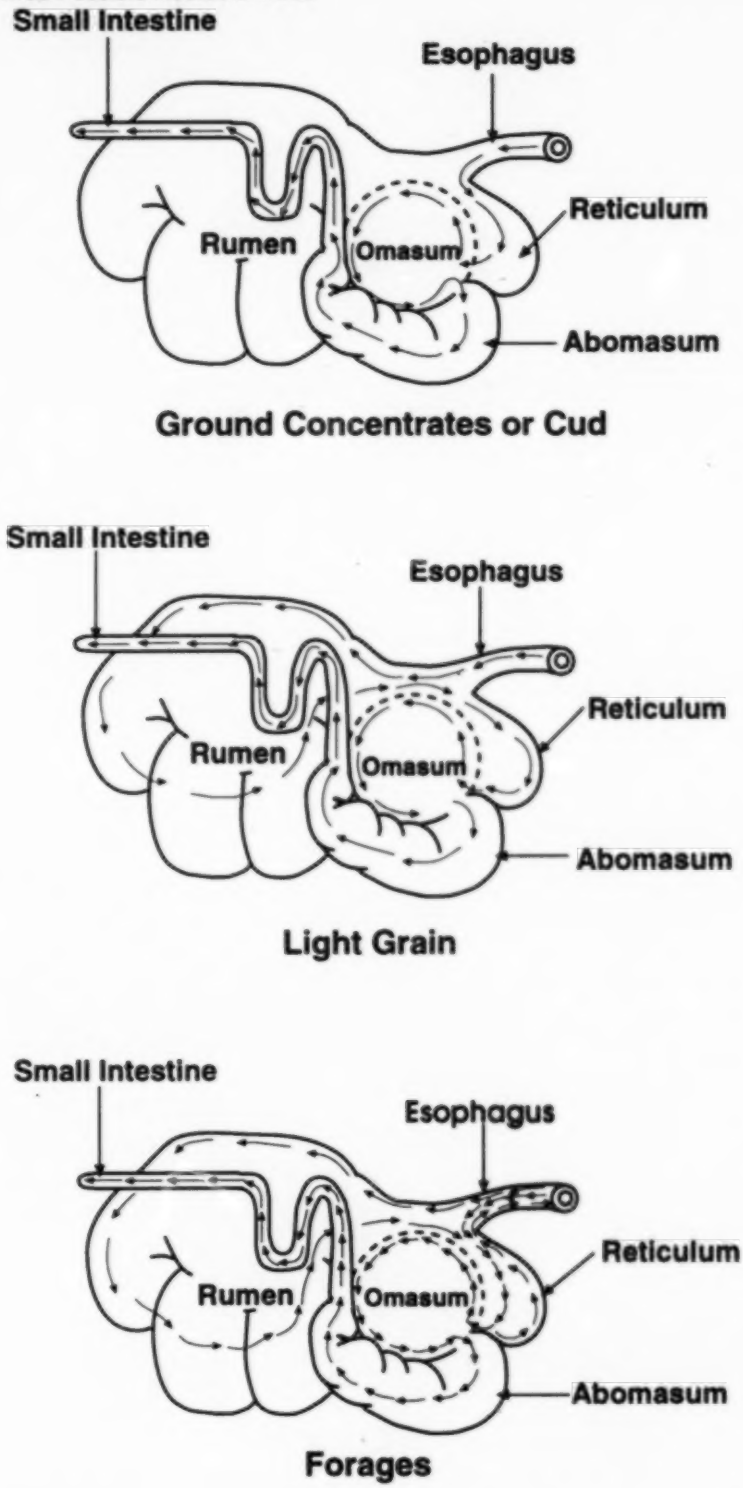
The Digestive Process

In ruminants, the breakdown of the nutrients in feed into a useable form is very complex. It involves not only the digestive juices and enzymes found in the monogastric system, but the activity of microorganisms found in the stomach. In addition, feed may take one of several paths as it passes through the stomach, depending on the nature of the feed.

In contrast to the monogastric digestive system, the process of digestion does not begin in the mouth in the ruminant, since enzymes are not present in the saliva of ruminants. Instead, digestion begins in the stomach.

Before feeds pass into the omasum and abomasum, they move through either the reticulum or the rumen and reticulum. Three types of microorganisms are present in the rumen and reticulum--bacteria, protozoa, and fungi. These microorganisms help to break down feed for digestion. Bacteria have the most important role in digestion. Some bacteria break down the more easily digestible sugars and starches. Other bacteria ferment the fiber found in roughage like hay, grass, and silage to break it down for use by the body. A second type of microorganism, protozoa, also aids the ruminant in digestion by storing sugars and starches, forming some microbial proteins from proteins in the diet, and fermenting fiber. The role of fungi, the final type of microorganism, is not clearly understood, but they play a role in the digestion of fiber. The action of all the microorganisms converts sugars, starches, and fiber into fatty acids.

Figure 2.3 - Three Possible Routes of Feed



In the stomach, feed may follow one of three routes, depending on the type of feed (see Figure 2.3). In the case of a ground concentrate or cud, the feed passes through the reticulum where the microorganisms act on it. It then passes through the omasum, where fatty acids are absorbed, to the abomasum. In the abomasum, gastric juices containing hydrochloric acid and the enzymes pepsin, rennin, and lipase are added to digest proteins and fats.

Light grains, such as oats and barley, require a slightly more complicated path to be utilized most efficiently. They first pass into the rumen, in which muscular action breaks the feed into smaller pieces. The microorganisms then assist in digestion, and the fatty acids that are produced are absorbed by the rumen. When the grain is sufficiently broken down, it passes through the reticulum and omasum into the abomasum.

The third route is that taken by forages. The combination of the action of the microorganisms and the path through the rumen and reticulum are what allows ruminants to better utilize forages, which have a high fiber content. As the forage passes into the rumen and reticulum, muscular action helps to break it down. The micro organisms then act on the pieces. After the microorganisms operate on the forage for a period of time, it moves to the reticulum. If the forage then needs to be broken down some more, the reticulum pumps it up through the esophagus into the mouth as cud to be chewed to break it into smaller pieces. After the cud has been chewed, the remains are again swallowed and enter the reticulum. They then pass to the omasum and abomasum.

After passing through the abomasum, the feed enters the small intestine. In the duodenum, pancreatic juices are added, which include the enzymes trypsin, chymotrypsin, lipase, and amylase (of which only a small amount is present). As in the monogastric system, trypsin and chymotrypsin act on proteins, lipase on fats, and amylase on starches. Bile from the liver is also added in the duodenum for the digestion of fats. Intestinal juices are added in the rest of the small intestine. The enzymes peptidase, lactase, sucrase, and maltase are found in the intestinal juices; peptidase works on proteins, while maltase, sucrase, and lactase work on sugars and starches. Maltase and sucrase are present in small amounts in ruminants.

Summary

A ruminant digestive system like that found in cattle and sheep has many parts that are similar to the monogastric digestive system. However, the stomach of the ruminant has four compartments instead of only one. These compartments are the rumen, reticulum, omasum, and abomasum. The structure of the stomach and microorganisms found in the rumen and reticulum enable the ruminant to digest forage much more efficiently than animals with a monogastric system.

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Water and feed contain substances called nutrients that are needed by an animal for its body to function. The monogastric and ruminant digestive systems are able to extract these elements through digestion. To ensure proper growth and efficiency in production, it is important to provide the proper levels of nutrients for an animal's nutritional needs.

Nutrients

Nutrients are elements or chemical compounds that support the life processes of an animal. They allow the animal to maintain its bodily functions by entering the cells of the body and fueling their growth and function. Nutrients are found in water, grain, roughage, and other food substances taken into the digestive system through the mouth.

Six Basic Nutrients

Six basic nutrients are essential for the survival of the animal. They are water, proteins, carbohydrates, fats, vitamins, and minerals. The lack of any one of these nutrients could cause problems for the animal.

Water is a liquid combination of hydrogen and oxygen. Since the body is made mostly of water, water has many important functions. For example, it plays a role in biochemical reactions like respiration, digestion, and assimilation (the transformation of nutrients from feed into body tissues). The transportation of nutrients and wastes through the body is also done by water. Water regulates body temperature and gives the body its form.

Proteins are compounds made up of substances called amino acids that contain the elements carbon, hydrogen, oxygen, and nitrogen; iron, phosphorus, or sulfur are also sometimes included. Protein is the only source of nitrogen for an animal. The amino acids can be divided into essential and nonessential amino acids (Figure 3.1). Essential amino acids must be provided in the diet because they are not found in animal tissues. Nonessential amino acids can be synthesized in animal tissues from other amino acids and therefore do not have to be supplied by the diet.

Protein has several functions. Protein is important because amino acids are the building blocks of body tissues. It develops and repairs body organs and tissues like muscles, nerves, skin, hair, hooves, and feathers. Protein is also used to produce milk, wool, and eggs. The fetus is developed and some enzymes and hormones are generated by the action of protein. It also forms a part of DNA.

Carbohydrates are made up of the elements carbon, hydrogen, and oxygen. A carbohydrate may be a sugar, starch, or fiber. Sugars and starches are easily digested, while fiber, which forms the cell wall material of plants, is more difficult to digest. The main function of carbohydrates is to provide the energy that powers muscle movement. Energy for muscular movement is required not only for exercise, but for many essential functions of the body, such as breathing, digestion, and the beating of the heart. Carbohydrates also produce body heat, and extra carbohydrates are stored as body fat.

Fats, like carbohydrates, are an energy source. The elements found in fats are the same as carbohydrates -- carbon, hydrogen, and oxygen. The difference between fats and carbohydrates is in the level of energy that they provide, with fats producing 2.25 times more energy than carbohydrates. In addition to serving as a

Table 3.1 - Essential and Nonessential Amino Acids

Essential Amino Acids	Nonessential Amino Acids
Arginine	Alanine
Histidine	Aspartic acid
Isoleucine	Citrulline
Leucine	Cysteine
Lysine	Cystine
Methionine	Glutamic acid
Phenylalanine	Glycine
Threonine	Lodogorgoic acid
Tryptophan	Proline
Valine	Serine
	Tyrosine
	Hydroxyglutamic acid
	Hydroxyproline

valuable energy source, fats also provide body heat and carry some vitamins.

Minerals are inorganic elements that are utilized by the body. They include both macro- and micro-minerals; macro-minerals are required in much larger amounts than micro-minerals. Minerals supply materials for building the skeleton and teeth and are a part of body regulators such as enzymes and hormones. They also assist in transmitting impulses through the nervous system, the development of body tissues, and muscular activity. Table 3.2 provides a listing of the minerals needed by the body.

Vitamins are fat- or water-soluble organic substances. The fat-soluble vitamins, carried by fats, are vitamin A, D, E, and K, which contain hydrogen, oxygen, and carbon. Water-soluble vitamins are vitamin C and the B-complex vitamins; they contain hydrogen, oxygen, carbon, chlorine, nitrogen, and cobalt or sulfur. Vitamins do not become a part of the body like the other nutrients. Instead, they regulate body functions. Vitamins regulate the digestion, absorption, and metabolism of nutrients. They also regulate the formation of new cells and the development of vision, bones, hair, feathers, skin, and muscles. Vitamins help protect against diseases and develop and maintain the nervous system.

Nutritional Needs of Animals

Nutritional needs vary depending on the needs of the animal for health and the life stages of maintenance, conception and gestation, lactation, and growth and development. When a female is in the gestational period, for example, nutritional needs are different than during lactation. Figure 3.1 demonstrates how the nutrient requirements of a mature female vary through different life stages.

Of the life stages, simple maintenance has the lowest level of nutritional requirements, and they must be met before other nutrient needs are considered. At this level, nutrients are used to maintain vital life processes and normal body temperature, with no weight gain or loss and no production (such as reproduction or fattening). The amount of feed needed to maintain an animal depends on the size of its body.

Table 3.2 - Macro- and Micro-minerals

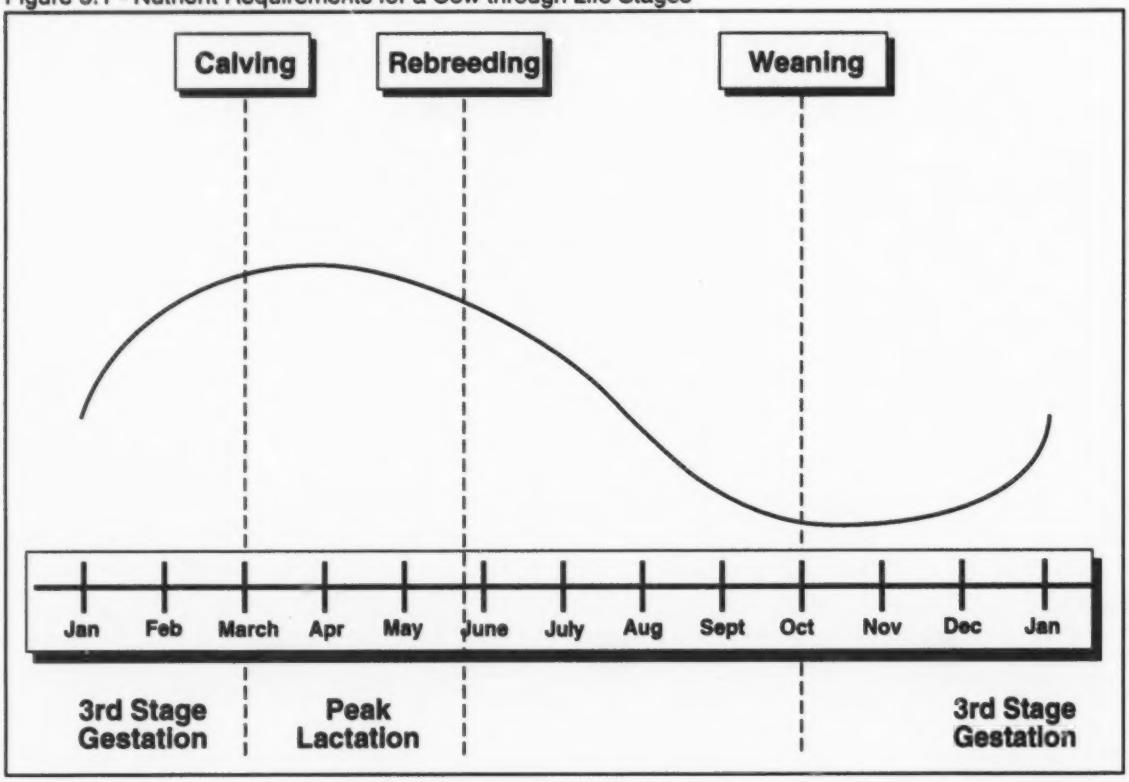
Macro-Minerals	Micro-Minerals
Calcium (Ca)	Iron (Fe)
Phosphorus (P)	Iodine (I)
Sodium (Na)	Copper (Cu)
Potassium (K)	Cobalt (Co)
Chlorine (Cl)	Fluorine (Fl)
Magnesium (Mg)	Manganese (MN)
Sulfur (S)	Zinc (Zn)
	Molybdenum (Mo)
	Selenium (Se)
	Chromium (Cr)

The main concern during conception and gestation is meeting additional nutritional needs to ensure good fetal growth and maintain the health of the mother. Most of the growing done by the fetus is done in the last trimester. During this time the female needs additional nutrients for itself and the fetus. The amount needed is equal to the nutrient needs of the young animal after birth and the maintenance needs of the female.

Lactation is milk production. Many additional nutrients are needed to produce milk, including proteins, minerals, vitamins, fats, and carbohydrates. Protein is important, since milk contains three percent protein. The energy supplied by fats and carbohydrates is vital for lactation. Water is also needed. Two minerals needed during lactation are calcium and phosphorus. Vitamin A and the B-complex vitamins are necessary as well when a female is lactating. If the animal is indoors, vitamin D may be needed.

An animal also has special nutrient requirements for growth and development. As it grows, the animal increases the number of cells at the tissue level. Muscles are built, and bone and connective tissues are produced. To accomplish this task, a increased amount of protein is needed. The minerals calcium and phosphorus are also required for bone growth. In addition, higher quantities of vitamins are required, especially vitamin D. An energy source is supplied by including more fats and carbohydrates in the animal's diet. If these nutrient requirements are not met while the animal is growing, the adult will be less productive.

Figure 3.1 - Nutrient Requirements for a Cow through Life Stages



Nutrients are important in maintaining the health or well-being of the animal in all of the life stages. Nutrients are needed to carry out vital bodily functions. An animal in the maintenance stage may not be gaining or losing weight, but it may not be as healthy as it could be. An animal must be healthy in order to be at its most productive.

Summary

Nutrients are elements and chemical compounds that nourish the body. The six basic nutrients are water, proteins, carbohydrates, fats, vitamins, and minerals. Each nutrient meets a specific need for maintenance, conception and gestation, lactation, growth and development, and health.

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When trying to feed an animal appropriately in order to meet production goals, the producer needs to consider both the nutrients provided in the feed and the nutrients needed by the animal. In order to meet the animal's nutritional needs, the nutrients in the feed have to match the animal's requirements.

Information Sources for Nutritional Requirements

A number of sources provide information that the producer can use to help him or her meet an animal's nutritional needs. For example, University Extension has livestock and dairy specialists and agricultural publications that are good information sources on nutritional needs. Extension guides that list nutritional information based on the animal's life stage, size, and weight are available for many animal species. The information is usually based on the work of the National Research Council (NRC) as well as research conducted in Missouri.

Another source of information is textbooks on animal nutrition. Many textbooks have tables, often in an appendix, that provide such information. Like the University Extension publications, textbooks list the animal's nutritional needs based on research and other publications.

Often feed companies and feed dealers can supply a producer with information on nutritional needs. The main business of feed companies and dealers is to sell products for feeding animals. Companies often put out publications about nutritional requirements of animals. The individual dealer also may make recommendations to the producer.

Finally, the National Research Council has conducted research to provide information on the minimum nutritional requirements needed by an animal to function properly. The NRC puts out its own publications detailing research findings.

Steps in Meeting an Animal's Nutritional Needs

Some general steps should be followed in order to meet the nutritional needs of animals. The goal of the step-by-step process is to meet the animal's needs through the nutrients provided in the feed. When trying to meet nutritional needs, the animal and the type of feed have to be taken into consideration.

1. Research needs to be done to learn the nutritional needs of the animal and the nutrient content of feeds. The first step is to find one of the information sources listed above. The source can then be used to obtain information on the requirements of that animal. Information on feeds may sometimes be found in the same source that provides data about the nutritional requirements of an animal. If information on feeds is not included, however, another source must be found.

2. After a source has been obtained, the nutritional needs of a particular animal need to be identified. This step has several parts. First, the life stage of the animal has to be identified. For example, a producer would have to know whether a cow was growing or breeding. Then the weight and frame size of the animal need to be determined. The producer next needs to determine the animal's desired performance, which is sometimes referred to as the rate of gain or average daily gain (ADG). Using this information, the producer can use the source to look up all the nutrients needed by the animal. Table 4.1 shows a section of a table that supplies information on nutrient requirements.

3. The next step in meeting an animal's nutritional needs is to identify the nutrients that are available in a specific feed. This part of the process is as important as identifying the animal's needs, since the feed must supply the required nutrients. This step also has several parts. First, the feeds that may be used must be identified. Many feeds may be available to the producer, such as corn, soybean meal, grass, and hay. Next, a version of a particular feed should be chosen to meet the animal's nutritional needs. For example, whole seed soybeans have a different amount of nutrients than dehulled soybean meal. The producer needs to

Table 4.1 - Nutrient Requirements Table

Weight (lbs.)	ADG (lbs.)	DM[b] (lbs.)	Protein (lbs.)	Ne_m Mcal	Ne_g Mcal	TDN (lbs.)	Ca (lbs.)	P (lbs.)
Medium-Frame Steer Calves								
400	2.5	11.0	1.56	3.81	3.16	8.1	.074	.033
400	3.0	10.0	1.65	3.81	3.86	8.5	.086	.037
500	0.5	11.5	0.98	4.50	0.64	6.2	.028	.019
500	1.0	12.3	1.16	4.50	1.37	7.2	.039	.024
500	1.5	12.8	1.33	4.50	2.13	8.1	.051	.028
500	2.0	13.1	1.49	4.50	2.93	8.8	.061	.031
500	2.5	13.0	1.63	4.50	3.74	9.6	.072	.035
500	3.0	11.8	1.69	4.50	4.56	10.0	.081	.037
600	.05	13.2	1.08	5.16	0.73	7.1	.030	.023
600	1.0	14.1	1.26	5.16	1.57	8.2	.039	.026

*From *Nutrient Requirements for Growing and Finishing Beef Cattle (G2067)*, University Extension agricultural publications, University of Missouri-Columbia

pick the right one for his or her purposes. In order to pick the appropriate feed, the producer has to know what level of nutrients is provided by that specific feed, which can be learned from the source used. Table 4.2 shows a portion of a sample feed nutrient composition table.

4. The final step is to match the feed to the animal's nutritional requirements to meet its needs. This step is accomplished by balancing a feed ration, which is covered at length in the next lesson.

Sources of Nutrients

In order to be able to supply the appropriate nutrients to an animal, a producer needs to know the sources of those nutrients. The six basic nutrients needed in an animal's diet--water, proteins, carbohydrates, fats, vitamins, and minerals--can be provided through various sources.

- Water - Found in fresh water or in feeds, which contain water
- Protein - Amino acids found in animal tissues, grains, and legumes

Table 4.2 - Feed Composition Table

	Dry Matter %	Crude Protein %	Ne_m Mcal/lb	Ne_g Mcal/lb	TDN %	Fat %	Crude Fiber %	Calcium %	Phos-phorus %	Potas-ium %	Sodium %	Sulfur %	Zinc PPM
Concentrates													
Molasses													
Beet	78.0	6.6	0.68	0.45	62	0.2	0.0	0.13	0.02	4.73	1.15	0.47	14
Cane	75.0	4.4	0.58	.037	54	0.1	0.0	0.75	0.08	2.88	0.17	0.35	23
Cane, dried	94.0	9.7	0.70	0.44	66	0.8	6.3	1.03	0.14	3.38	0.19	0.43	31
Oats													
Grain	89.0	11.8	0.75	0.49	69	4.8	10.8	0.06	0.34	0.39	0.07	0.20	37
Mill Byproduct	89.0	7.1	0.34	0.00	29	2.3	22.3	0.11	0.21	0.53	-.-	0.21	-.-
Groats	90.0	15.9	0.95	0.65	85	6.2	2.5	0.07	0.43	0.35	0.05	0.20	0

*From *Feed Composition Tables (G2051)*, University Extension agricultural publications, University of Missouri-Columbia

- Carbohydrates - Sugars, starches, or fibers found in grains and forages
- Fats - Fatty acids found in animal tissues, fats, and grains
- Vitamins - Found in grass, sun-cured hay, and commercial feeds
- Minerals - Found in plant and animal tissues and commercial feeds

Summary

Information on nutritional requirements of animals and the nutrient content of feeds can be learned from many sources. Once sources of information on requirements and the nutrients in feeds are found, the animal's needs may be met by identifying its requirements and then the nutrients of the available feed. Each of the six basic nutrients can be provided by a number of sources.

Credits

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G2067: *Nutrient Requirements for Growing and Finishing Beef Cattle*

Warren, D. M. *Small Animal Care and Management.* Albany, NY: Delmar Publishers, 1995.

Once a producer has determined the nutritional needs of an animal and the nutrient content of feeds, the next step is balancing a ration. A balanced ration provides the needed nutrients for the animal by including the necessary amounts of the proper feeds.

Importance of Balanced Rations

A balanced ration provides the proper levels of nutrients for an animal. The objective of balancing a ration is to meet the animal's nutritional needs with feed that supplies each nutrient in the proper amount and proportion. See Figure 5.1.

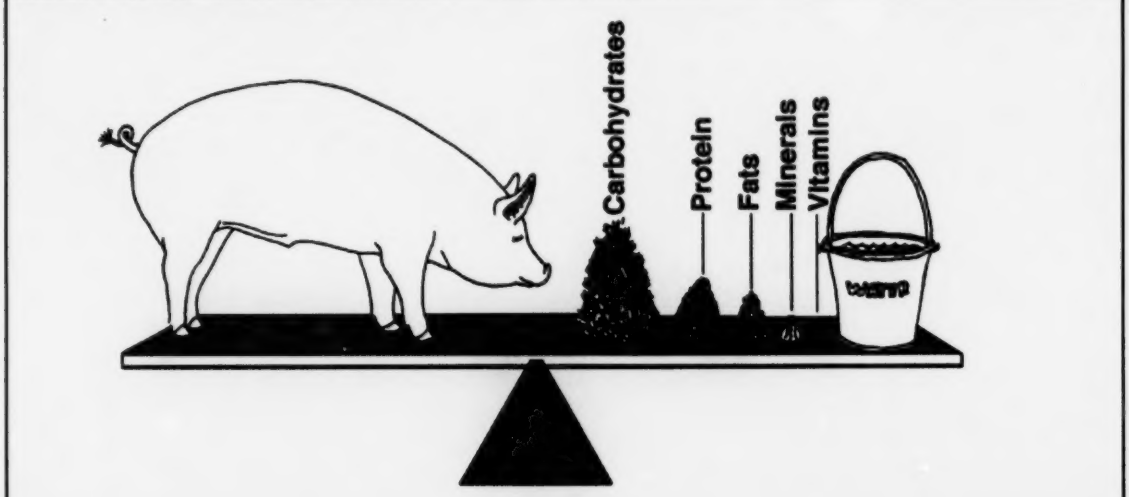
Providing animals with balanced rations is important. Balancing rations will allow a producer to meet an animal's nutritional needs for health and the specific nutrient requirements of each life stage--maintenance, conception and gestation, lactation, and growth and development. By balancing rations, nutritional deficiencies that can harm the animal can be prevented. In addition, growth and production can be maximized.

Balancing Rations

Several methods may be used to balance a ration. Special computer programs, trial and error, and the Pearson square method may all be utilized by the producer when balancing a ration. In addition to these common methods, many other methods are available to producers.

Today, computers are widely used when balancing rations. Local feed dealers, cooperatives, companies, and producers may balance a ration using computers. Special programs have been designed to check that the feeds included in a ration meet all of the animal's nutrient requirements by making sure they are balanced. The computer does the figuring with the information provided about the animal and the type and amount of feed. It therefore requires complete information for accurate results. When this data is entered, the program will indicate whether the ration is balanced, the animal needs more of a certain nutrient or nutrients, or the ration is exceeding the animal's needs. If the ration is not balanced, the person using the program must alter the ration and enter the new information to allow the computer to check it. The operator of the program must therefore be knowledgeable about nutrition for accurate results. A general knowledge of nutrition is necessary because even if a ration balances, an animal will not eat it if it is not palatable.

Figure 5.1 - Balancing Nutrients in Rations



When all of the nutrient needs of an animal are supplied, the ration is balanced.

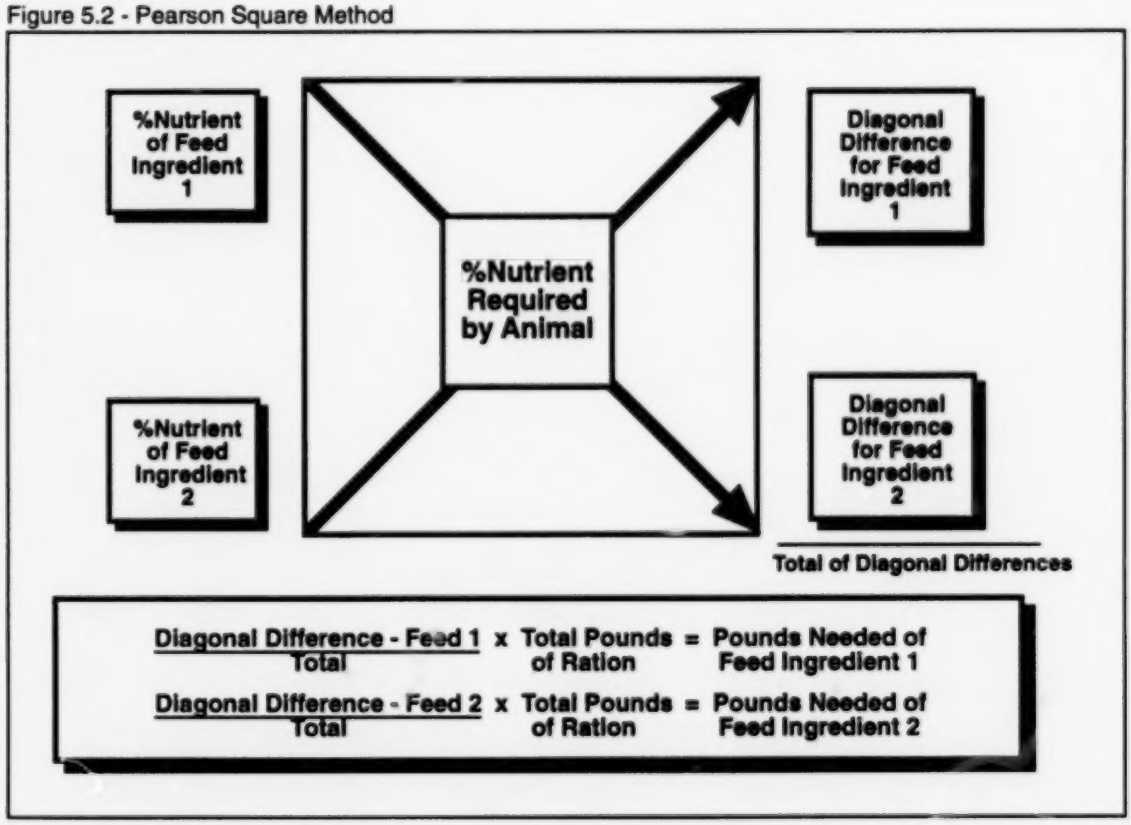
Another method for balancing rations is referred to as the trial and error method. To use this method, a combination of feeds is selected that the producer believes will meet nutritional needs. The nutrient content of the diet is calculated and compared to the nutritional requirements of the animal. If the diet does not meet those requirements, a different combination of feeds must be selected and the process repeated. The producer attempts to meet all the animal's nutrient needs with this method.

A third method, the Pearson Square method, can also be used to balance rations. This method balances for only one nutrient at a time; it is most often used for crude protein. In order to balance for other nutrients, a new Pearson square must be constructed. This method is sometimes utilized by a producer engaged in limited production. It is a good way to start learning how to balance rations.

The process for using the Pearson Square is quite simple. First, draw a square similar to that in Figure 5.2. Write the percent of the nutrient required by the animal in its diet in the middle of the square. Next, assign each of two feed ingredients its own corner on the left side and write down the percent of the nutrient required found in that ingredient. Find the difference by subtracting diagonally through the square; always subtract the smaller number from the larger number. Write the results on the right corners of the square. The answer in the upper right corner represents the proportion of the ingredient in the upper left corner that will be included in the ration, while the answer in the lower right corresponds to the proportion of the ingredient on the lower left that is included. Next add the numbers in the right-hand corners and place a total at the bottom.

Once the square has been completed, some additional calculations must be done to determine the amounts and proportions of feeds needed. First, a percentage is found for the ingredients by taking the diagonal difference for each ingredient and dividing it by the total. This number is the

Figure 5.2 - Pearson Square Method


%Nutrient of Feed Ingredient 1
%Nutrient Required by Animal
Diagonal Difference for Feed Ingredient 1
%Nutrient of Feed Ingredient 2
Diagonal Difference for Feed Ingredient 2
Total of Diagonal Differences
Diagonal Difference - Feed 1 / Total x Total Pounds of Ration = Pounds Needed of Feed Ingredient 1
Diagonal Difference - Feed 2 / Total x Total Pounds of Ration = Pounds Needed of Feed Ingredient 2

percentage of that ingredient needed in the ration in order for the ration to balance. After the percentage of each feed ingredient is found, the number of pounds of feed can be determined by multiplying the percentage by the total number of pounds in the ration. After the ration is balanced for one nutrient using this method, the producer must still check to ensure that the proper amounts of other nutrients are supplied to the animal.

Figure 5.3 shows an example of the use of the Pearson Square method. Suppose that 12 percent crude protein is needed in a concentrate mix for steers. The producer has to determine how many pounds of corn, which has 9 percent crude protein, and how many pounds of a protein supplement that has 40 percent crude protein are needed for a 100 pound ration.

The producer first constructs a square showing the percentages. He or she then subtracts the smaller number from the larger and adds the two remainders; the calculations show that there are 28 pounds of corn and 3 pounds of supplement in 31 pounds of feed. The amounts of the two ingredients in a hundred pound ration are determined by dividing the number of pounds of each ingredient by 31 and multiplying the result by 100. The producer determines that 90.3 pounds of corn and 9.7 pounds of supplement should be included in the ration.

Factors Influencing Ration Ingredients

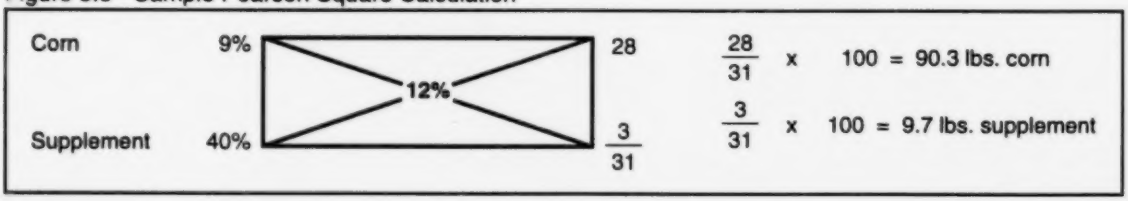
Many different feeds can be used to meet an animal's nutritional requirements. A combination of feeds can also be used. The selection of a feed or combination of feeds for the animal is influenced by two factors, least cost and ingredient availability.

The term least cost refers to getting the desired performance at the least cost to the producer. The type of nutrients needed by the animal cannot be ignored on the basis of cost, however. Suppose corn is $2 a bushel, while wheat can be bought for $4 a bushel. Which one should be fed? If the corn is chosen because it is cheaper and corn does not meet the nutritional needs of the animal, then in the long run costs may actually be greater, since growth and production are not maximized.

The process for determining least cost is not complicated. First, each feed ingredient in a ration has to be balanced. Once the amount of a particular feed ingredient is known, the total cost of the ration can be calculated by multiplying the quantity of each feed by its price and then adding to find total cost. The costs of balanced rations using different feed ingredients can then be compared. Choosing one ration over another ration that supplies the same nutrients to the animal will depend on which ration has the least cost.

The other factor that influences feed selection is ingredient availability. The availability of a particular feed depends on the geographical area. Areas vary in the types of feeds that are available. For example, in places where grains are grown extensively, corn will be more available as a feed ingredient. Areas with an abundance of good grazing, on the other hand, will utilize forages for feed. In addition, different types of manufacturing may produce byproducts that are available as feed to animals. Manufacturing byproducts that are fed to animals include items such as fish meal, blood meal, brewer's grains, whole cottonseeds, and soyhulls. Ingredient availability therefore depends on what is grown or manufactured in a certain area.

Figure 5.3 - Sample Pearson Square Calculation



Summary

A balanced ration provides the animal the proper amounts and proportions of nutrients. It is important to balance a ration to keep an animal healthy and provide the necessary nutrients for each life stage, to prevent nutritional deficiencies, and to promote maximum growth and production. A ration may be balanced using a variety of methods, such as computer programs, trial and error, and the Pearson Square method. Least cost and ingredient availability are factors to consider when choosing the ingredients of a ration.

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